PARASITOLOGY

CAMBRIDGE UNIVERSITY PRESS
LONDON: FETTER LANE, E.C. 4

H. K. LEWIS AND CO., LTD., 136, GOWER STREET, LONDON, W.C. 1
WHELDON AND WESLEY, LTD., 2–4, ARTHUR STREET, NEW OXFORD STREET, LONDON, W.C. 2
CHICAGO: UNIVERSITY OF CHICAGO PRESS
(AGENT FOR THE UNITED STATES)
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PARASITOLOGY

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VOLUME XVI 1924

CAMBRIDGE

AT THE UNIVERSITY PRESS

1924

PRINTED IN GREAT BRITAIN

Med.
Faxon

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APR 7 1924
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Vol. 16, No. 1 January 1924

Vol 16-17

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Quick Professor of Biology and Director of the Molteno Institute for Research in Parasitology in the University of Cambridge

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CAMBRIDGE UNIVERSITY PRESS
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LONDON: FETTER LANE, E.C. 4
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Cambridge University Press, Fetter Lane, London, E.C.4; C. F. Clay, Manager

VOLUME XVI JANUARY, 1924 No. 1

HETEROPHYIDÉS DE LA FAUNE PARASITAIRE DE ROUMANIE.

PAR J. CIUREA,

Professeur de Parasitologie à la Faculté de Médecine Vétérinaire de Bucarest.

(Avec les Planches I—V.)

DANS ce travail je m'occuperai des questions suivantes:

I. Heterophyidés des oiseaux.

II. Heterophyidés des mammifères domestiques (chien, chat et porc).

III. Les métacercaires du *Metagonimus romanicus* (Ciurea, 1915) et d'*Apophallus Mühlingi* (Jägerskiöld, 1889), leur morphologie et leur évolution jusqu'à l'état adulte.

IV. La distribution géographique des Heterophyidés connus jusqu'à présent.

V. Les mêmes espèces de trématodes peuvent-elles parasiter les oiseaux et les mammifères?

VI. Division de la famille des Heterophyidés en cinq sous-familles.

I. HETEROPHYIDÉS DES OISEAUX.

Cryptocotyle jejuna (Nicoll, 1907) (Pl. I, fig. 1).

Ce trématode a été trouvé par Nicoll dans l'intestin du *Totanus calidris* L. dans la Grande-Brétagne.

J'ai trouvé aussi le *Cryptocotyle jejuna* assez fréquemment chez des mouettes argentées (*Larus argentatus cachinnans* Pall.) et deux fois chez des sternes hirondelles (*Sterna hirundo* L.), chassées au mois de Juin 1912 et 1913 à Somova (Départ. Tulcea). Chez les mouettes l'infestation a été presque toujours en masse, tandis que chez les sternes je n'ai trouvé que deux exemplaires.

Par leurs caractères morphologiques, mes spécimens de *Cryptocotyle jejuna* ressemblent assez bien à ceux de Nicoll, seulement ils sont un peu plus petits, 0·92–1·47 mm. en longueur et 0·30–0·50 mm. en largeur (Nicoll, longueur maxima 1·8 mm., largeur $\frac{1}{8}$–$\frac{1}{4}$ de la longueur du corps).

Je ne suis pas d'accord avec d'autres auteurs (Mühling, Jägerskiöld) en ce qui concerne l'origine qu'ils donnent à la ventouse génitale des Cryptocotylinés (*Cryptocotyle* et *Scaphanocephalus*). Nous savons que cette ventouse est une cavité, avec des parois musculaires, située au milieu du corps, où débouchent le canal éjaculateur et le vagin. Dans l'intérieur de la ventouse on trouve en haut une ventouse ventrale sans membrane limitante externe et en bas une

papille musculeuse ("kegelförmige Körper" d'Jägerskiöld), qui présente, à partir de sa face ventrale vers le centre, une zone ovalaire parenchymateuse ("Zunge" d'Jägerskiöld).

D'après ces auteurs la ventouse génitale des Cryptocotylinés ne serait qu'une ventouse génitale de type *Heterophyes*, qui a attiré à son intérieur la ventouse ventrale, et la papille musculeuse ne serait qu'un organe qui sert à la fixation de deux individus pendant leur copulation réciproque (voir Jägerskiöld, *Scaphanocephalus expansus*, pag. 10, fig. 3 du texte).

D'après mon avis, la constitution de la papille nous indique qu'elle n'est qu'une ventouse atrophiée par la disparition de sa lumière, qui a été comblée par du tissu parenchymateux. A l'appui de cette opinion vient encore le fait que la ventouse ventrale chez ces distomes est aussi en voie d'atrophie. Il s'en suit que c'est seulement cette papille qui doit être considérée comme l'homologue de la ventouse génitale des Heterophyinés, tandis que la ventouse génitale, décrite par d'autres auteurs, ne serait qu'un enfoncement du corps au niveau des ventouses ventrale et génitale. Je désignerai cet enfoncement *sinus génital*.

Apophallus Mühlingi (Jägerskiöld, 1889) (Pl. I, fig. 2).

Apophallus Mühlingi a été rencontré jusqu'à présent chez les oiseaux suivants: *Larus ridibundus* L. (Mühling, 1897), *Phalacrocorax carbo* (L.), *Himantopus himantopus*, et *Cancroma cochlearis* (Kotlán, 1922).

J'ai récolté ce trématode très souvent et en grand nombre au mois de Juin 1912 et 1913 dans l'intestin de *Larus argentatus cachinnans*, de *L. ridibundus* et d'un jeune *Pelecanus onocrotalus* L. couvé dans la delte du Danube (Rossetti).

Je dois signaler que mes exemplaires d'*Apophallus Mühlingi* sont plus grands (0·99–3·01 mm. en longueur et 0·18–0·30 mm. en largeur) que ceux de Mühling et de Kotlán. De même, chez mes spécimens le sinus génital est situé avant le milieu de la longueur du corps, tandis que chez ceux de Mühling il est placé au milieu du corps. D'après la description et la figure de Mühling on peut voir que cet auteur n'a pas remarqué que la ventouse ventrale siège à l'intérieur d'un sinus génital resulté, je crois, par le même mécanisme que chez les Cryptocotylinés. De même, il n'a pas décrit les deux papilles génitales, en croissant, situées au dessus de la ventouse ventrale et attachées par leur base à la paroi dorsale du sinus, entre lesquelles vient s'ouvrir le canal éjaculateur et le vagin.

Pygidiopsis genata Looss, 1907.

Looss a trouvé quelques exemplaires de ce trématode dans l'intestin du pélican (*Pelecanus onocrotalus* L.) en Egypte. J'ai trouvé de nombreux spécimens dans l'intestin d'un *P. onocrotalus*, mort au mois de Janvier 1913 à la Station de Pêcherie Tulcea.

Les exemplaires de *Pygidiopsis genata* que j'ai trouvés en Roumanie sont un peu plus grands (0·58–0·78 mm. en longueur et 0·25–0·34 mm. en largeur) que ceux décrits par Looss en Egypte.

A la description donnée par Looss à ce distome, je n'ai à ajouter que quelques détails un peu plus précis, relativement au siège de la ventouse ventrale et du sinus génital, ainsi que quelques considérations sur l'origine du corps lenticulaire qui se trouve à l'intérieur du sinus.

Looss a figuré la ventouse ventrale et le sinus génital dans le plan médian du corps. D'après mes observations, le centre de la ventouse ventrale se trouve un peu à droite et celui du sinus à gauche du plan médian.

Résumons la description donnée par cet auteur au sinus génital de ce trématode: Le pore génital est situé à peu près dans le plan médian du corps et au dessus de la ventouse ventrale. Il est représenté par une fente large et profonde, dont la moitié droite se continue avec le vagin, tandis que la moitié gauche conduit à un corps lenticulaire creux, un peu plus petit que la ventouse ventrale. La paroi interne de ce corps lenticulaire forme des plis irradiant en éventail vers la périphérie.

Sur des sections longitudinales et transversales, que j'ai faites à des exemplaires de *Pygidiopsis genata*, j'ai pu constater que le corps lenticulaire est formé de rares fibrilles ayant l'apparence de fibres musculaires atrophiées. De même, j'ai observé que les plis de la paroi interne du corps lenticulaire se colorent en bleu foncé par hémalun. Ils se présentent comme des petits bâtonnets, plus ou moins semblables aux aiguillons de la ventouse génitale des Heterophyinés. En me basant sur ces détails, je crois que ce corps lenticulaire creux n'est qu'une ventouse génitale dégradée du type *Heterophyes*.

L'étude que j'ai faite à cette occasion, sur la ventouse ventrale et sur les différentes formations papillaires du sinus génital des Heterophyidés, m'a conduit aux conclusions suivantes:

(*a*) Le type primitif de cette famille a dû avoir près de la ventouse ventrale une ventouse génitale, plus ou moins semblable à celle des Heterophyinés.

(*b*) La ventouse génitale de quelques représentants de ce type [les Centrocestinés (en partie), les Métagoniminés et les Apophallinés] au cours de l'évolution s'est enfoncé dans le corps et s'est atrophiée. De cette manière les formations papillaires, que nous trouvons actuellement chez ces distomes, ne sont que les vestiges de la ventouse génitale du type primitif.

(*c*) Chez d'autres (les Cryptocotylinés), non seulement la ventouse genitale, mais aussi la ventrale s'est cachée dans le corps et s'est atrophiée.

(*d*) En fin, je crois que *Monostomum pumilio* Looss n'est qu'un Heterophyidé, dont les ventouses ventrale et génitale ont complètement disparues.

Metagonimus dobrogensis (Ciurea, 1915)[1].

Ce distome a été trouvé dans l'intestin d'un jeune pélican (*Pelecanus onocrotalus* L.) de la delta du Danube.

[1] En 1913 Katsurada a institué le genre *Metagonimus* pour un trématode, trouvé par Yokogawa (*Metagonimus Yokogawai*) au Japon. Sans avoir eu connaissance de ce travail, j'ai proposé en 1915 le genre *Loossia* pour trois distomes que j'ai trouvé en Roumanie chez le chien, le porc (*Loossia romanica*), le chat (*L. parva*) et chez le *Pelecanus onocrotalus* (*L. dobrogensis*), ressemblant

II. HETEROPHYIDÉS DES MAMMIFÈRES DOMESTIQUES (CHIEN, CHAT ET PORC).

Rossicotrema donicum Skrjabin, 1919 (Pl. I, figs. 3, 4).

Skrjabin a trouvé ce trématode en Russie dans l'intestin des chiens de Novotscherkassk.

J'ai récolté trois exemplaires de *Rossicotrema donicum* de l'intestin grêle d'un chien tué le 7 Juin 1913, à la Station de Pêcherie de Somova. De même, j'ai recueilli six spécimens chez trois chiens nourris expérimentalement: l'un avec du rotengle (*Scardinius erythrophthalmus* (L.)), l'autre avec de la brême (*Abramis brama* (L.)) et le troisième avec de la brême bordelière (*Blicca björkna* (L.)). Il résulte que ces poissons doivent être considérés comme les hôtes intermédiaires des métacercaires de ce trématode.

Mes exemplaires de *Rossicotrema donicum* sont un peu plus petits (0·73 mm. longueur et 0·33 mm. largeur) que ceux trouvés en Russie (1·30 mm. de long et 0·58–0·72 mm. de large).

Je dois ajouter à la description de Skrjabin, que ce distome possède deux papilles musculeuses à l'intérieur du sinus génital, qui prennent naissance de la paroi dorsale. Je crois encore, que le canal éjaculateur et le vagin s'ouvrent séparément dans le sinus, entre les deux papilles mentionnées, tandis que Skrjabin est d'avis que le canal éjaculateur s'unit avec l'utérus à une petite distance, avant son débouchement dans le sinus génital.

Apophallus Mühlingi (Jägerskiöld, 1889) (Pl. II, figs. 7–8).

Chez les chiens nourris expérimentalement avec de la brême bordelière (*Blicca björkna*), j'ai trouvé presque toujours dans l'intestin grêle quelques exemplaires d'*Apophallus Mühlingi*, mais seulement chez ceux qui étaient sacrifiés environ entre 4–15 jours après l'infestation[1].

par la plupart de leurs caractères à *Metagonimus Yokogawai*. Comme nous voyons, il s'agit de deux genres, *Metagonimus* et *Loossia*, qui contiennent des trématodes semblables.

De ces deux genres, conformément à la loi de priorité, on doit conserver le plus ancien, c'est à dire le genre *Metagonimus*, tandis que *Loossia* tombe en synonymie. Conséquemment mes espèces de *Loossia* doivent rentrer dans le genre *Metagonimus* et seront nommé *M. romanicus*, *M. parvus* et *M. dobrogensis*.

Mes dernières recherches m'ont prouvé que *M. parvus* est identique à *M. romanicus*; donc il reste seulement deux de ces espèces, dont l'une, *M. romanicus*, vit en parasite chez le chien, le chat et le porc, et l'autre, *M. dobrogensis*, chez le pélican.

Ransom, dans son synopsis sur les trématodes de la famille des Heterophyidés (1920), a identifié tous mes espèces de *Metagonimus* avec *M. Yokogawai*. Ce qui différencie les espèces roumaines de *Metagonimus* de celle du Japon, c'est que, chez les premières, il y a à l'entrée du sinus génital une seule papille placée en bas, tandis que chez la dernière il existe deux papilles, dont l'une plus grande est située en haut et l'autre plus petite en bas. Cela résulte, d'ailleurs, d'une façon précise de la description et des figures d'Yokogawa et des miennes.

[1] Le fait, que je n'ai pas pu trouver l'*Apophallus Mühlingi* chez les chiens, que pendant les premiers 15 jours après l'infestation, s'explique, probablement, par cela que ce trématode, étant un parasite des oiseaux, ne peut pas s'accommoder longtemps chez les mammifères (comme nous allons voir un peu plus loin).

Ces *A. Mühlingi*, provenant du chien, ressemblent assez bien à ceux des oiseaux, avec la seul différence morphologique qu'ils sont un peu plus petits, 1·08–1·32 mm. en longueur et 0·24–0·29 mm. en largeur (pour les exemplaires âgées de 10–15 jours).

Metagonimus romanicus (Ciurea, 1915).

J'ai trouvé ce trématode chez le chien, le chat et le porc. Chez les deux premiers dans l'infestation naturelle et expérimentale, tandis que chez le dernier seulement expérimentalement.

III. LES MÉTACERCAIRES DU *METAGONIMUS ROMANICUS* ET D'*APOPHALLUS MÜHLINGI*, LEUR MORPHOLOGIE ET LEUR ÉVOLUTION JUSQU'À L'ADULTE.

Après avoir déterminé, durant les années 1913–1914, les principales espèces de poissons du Danube (*Blicca björkna* (L.)) et *Idus idus* (L.)), par la consommation desquels le chien, le chat et le porc s'infestent avec *Metagonimus romanicus*, j'entrepris des recherches les années suivantes pour trouver les métacercaires de ce trématode dans le corps de ces poissons.

Dans ce but, j'ai examiné au microscope différents tissus et organes de la brême bordelière (*Blicca björkna*) et de l'ide jesse (*Idus idus*).

Le résultat de ces recherches confirma mes prévisions. J'ai trouvé chez ces poissons des petites métacercaires enkystées dans les écailles, dans la musculature et dans les nageoires. Mais la présence d'un pigment noir, autour des métacercaires de la musculature et des nageoires, et son absence chez ceux des écailles, m'a fait douter que toutes ces métacercaires appartiendraient à la même espèce. Cela en raison du fait déjà connu, que chez d'autres larves de trématodes qui vivent en parasites chez les poissons, comme *Diplostomum cuticula* v. Nordmann (voir Pl. III, fig. 12), la pigmentation noire autour des kystes larvaires s'observe dans n'importe quelle partie du corps où ces larves ont leur siège.

Ce qui m'a fait encore douter que les métacercaires des écailles seraient les mêmes que celles de la musculature et des nageoires, c'était aussi le fait, que les poissons, provenant des différents transports, présentaient, soit seulement l'infestation des écailles, soit celle de la musculature et des nageoires. Très rarement on trouvait des poissons, dont toutes ces parties du corps furent infestées avec ces métacercaires.

En effet, mes recherches, basées sur la morphologie des métacercaires et sur leur évolution jusqu'au trématode adulte, m'ont démontré, comme nous allons voir, que les métacercaires des écailles appartiennent à *Metagonimus romanicus* et ceux de la musculature et des nageoires, à l'*Apophallus Mühlingi*.

La morphologie de la métacercaire du Metagonimus romanicus

(Pl. II, fig. 9; Pl. I, fig. 5).

La métacercaire du *Metagonimus romanicus* se trouve enkystée dans les écailles de différentes espèces de poissons de la famille des Cyprinidés, spécialement de la brême bordelière et de l'ide jesse, qui doivent être considérés comme les principaux hôtes intermédiaires de la métacercaire de ce trématode.

La forme du kyste ressemble à celle d'une lentille circulaire ou légèrement elliptique, biconvexe, mesurant 0·18–0·24 mm. de long et 0·14–0·19 mm. de large. Sa capsule interne est une membrane hyaline 0·004–0·013 mm. de grosseur.

Le nombre des métacercaires qui vivent en parasites dans une écaille varie selon l'intensité de l'infestation—le plus grand nombre que j'ai observé fut de 20.

Le siège de prédilection est la moitié postérieure (libre) de l'écaille et seulement dans les invasions massives on les observe aussi dans la moitié antérieure (fixée). Rarement ils infestent le canal de la ligne latérale de l'écaille. Dans l'épaisseur des écailles, les métacercaires sont toujours plus rapprochées de la face interne.

La métacercaire enkystée se trouve le plus souvent repliée sur sa face ventrale et remplit presque complètement la cavité du kyste. A un fort grossissement on peut distinguer: les petites écailles cuticulaires disposées en quinconce; les ventouses buccale et ventrale et les corpuscules calcaires sphériques, réfringents de la vésicule excrétoire qui occupe l'extrémité postérieure du corps sous la forme d'une tache noire très caractéristique. Ce sont ces corpuscules calcaires qui, à la lumière transmise, donnent l'aspect noir de la vésicule excrétoire.

Les métacercaires sont très mobiles à l'intérieur du kyste et j'ai pu les maintenir vivantes plus de 40 jours en conservant les écailles parasitées dans de l'eau de canal, seulement ayant soin de la renouveler de temps en temps, pour empêcher la putréfaction. Après un séjour plus long dans l'eau, la vesicule excrétoire prend la forme d'une Y.

La mort des métacercaires enkystées est facile à saisir par ce qu'ils ne remplissent plus complètement le kyste et qu'on ne peut plus reconnaître les écailles cuticulaires, les organes internes et les corpuscules de la vésicule excrétoire.

La métacercaire, dégagée de son kyste dans une goutte d'eau, se meut lentement, se contracte et s'allonge, pouvant atteindre 0·38 mm. de longueur. Conservée dans l'alcool (70 pour cent.), elle se présente sous la forme d'une petite languette, mesurant environ 0·37 mm. de long et 0·10 mm. de large. Ventouse buccale 0·055 mm. transversalement; prépharynx 0·022 mm. de long; pharynx elliptique 0·033 mm. en longueur et 0·022 mm. en largeur; œsophage long (0·18 mm.); bifurcation de l'intestin presque au milieu de la longueur du corps; branches intestinales s'étendant jusqu'à l'extrémité pos-

térieure. Le sinus génital, en forme d'une petite poche ovale, siège en arrière du milieu du corps et du côté droit. Il est très rapproché de la branche intestinale correspondante et contient en bas la ventouse ventrale (0·039: 0·028 mm.) et en haut une petite papille génitale très peu distincte. La vésicule excrétoire, en forme d'une Y, occupe la plus grande partie de la moitié postérieure du corps. Ses canalicules excréteurs latéraux s'observent seulement dans la moitié antérieure du corps. Les ébauches des testicules sont représentées par deux petits groupes cellulaires, situés sur les côtés latéraux de la vésicule excrétoire —le gauche plus haut que le droit. Les ébauches de l'ovaire et du réceptacle séminal sont placées au dessus de l'extrémité antérieure de la vésicule.

L'évolution de la métacercaire du Metagonimus romanicus jusqu'à l'état adulte.

J'ai suivi l'évolution de ce trématode de la manière suivante: J'ai nourri de jeunes chiens (un seul repas) avec des écailles infestées de métacercaires et j'ai sacrifié ces chiens à des intervalles déterminés pour retrouver les distomes qui se sont développés dans leur intestin.

Pour recueillir les trématodes du contenu intestinal, je procède toujours de la façon suivante: D'abord je divise l'intestin grêle en trois portions: antérieure, moyenne et postérieure. Après cela je racle avec une spatule le contenu intestinal de chaque portion et je le met séparément dans un tube à essai de grande dimension, rempli à moitié avec de l'alcool de 70 pour cent. Dans le but de débarrasser les trématodes des mucosités adhérentes, j'agite fortement le mélange au moment du fixage. A cette occasion, je crois intéressant de signaler que l'agitation du liquide fixateur évite en même temps l'enroulement des distomes vivants pendant la fixation. Par cette méthode, j'obtiens les parasites allongés et prêts à être examinés. Après l'avoir fixé pendant une $\frac{1}{2}$–1 heure dans de l'alcool, je lave ce matériel avec de l'eau ordinaire jusqu'à ce qu'il devient assez transparent pour pouvoir distinguer les trématodes à l'examen microscopique.

Je dois encore mentionner que mes observations, sur l'évolution des métacercaires du *Metagonimus romanicus* et d'*Apophallus Mühlingi*, et les observations d'Yokogawa, sur l'évolution des métacercaires du *Metagonimus Yokogawai*, conduisent à la conclusion, que nous avons à faire chez ces Heterophyidés avec une évolution particulière, n'ayant pas encore été décrite jusqu'à présent chez les trématodes. Il s'agit d'une migration de ces métacercaires, après leur sortie des kystes, dans la paroi de l'intestin, où ils se développent jusqu'au moment de la fécondation (environ trois jours), quand ils reviennent comme parasites adultes dans la lumière de l'intestin. Ainsi l'étude de leur évolution peut être partagée en deux périodes: l'évolution de la métacercaire jusqu'au trématode fécondé et l'évolution après la fécondation.

(*a*) *L'évolution de la métacercaire du Metagonimus romanicus jusqu'au trématode fécondé.*

En nourrissant des jeunes chiens avec des écailles infestées et en les sacrifiant 3 heures, 12 heures et 3 jours après l'ingestion des métacercaires, je n'ai pu trouver à l'autopsie aucun distome dans la lumière de l'intestin. Dans le nombre restreint de sections que j'ai faites, dans la paroi intestinale de la région jéjunale d'un chien infesté depuis trois jours, j'ai trouvé un jeune *Metagonimus romanicus* (pas encore fécondé) engagé presque complètement dans une glande de Lieberkühn.

(*b*) *L'évolution du Metagonimus romanicus après la fécondation* (Pl. I, fig. 6; Pl. II, figs. 10, 11).

Le quatrième jour après l'ingestion, le parasite revient dans la lumière de l'intestin, principalement dans le tiers moyen; il mesure environ 0·64 mm. en longueur et 0·27 mm. en largeur. La fécondation a eu lieu. On peut voir les spermatozoïdes dans la vésicule séminale et dans l'utérus. De même, il y a déjà quelques œufs dans la partie inférieure de l'utérus (j'ai pu compter jusqu'à neuf). Le réceptacle séminal est dépourvu de sperme. Ce qui frappe chez ces individus, c'est l'absence des œufs dans les circonvolutions utérines du tiers moyen du corps.

Le cinquième jour, ce distome mesure 0·82 mm. de long et 0·29 mm. de large; les organes génitaux dépassent le tiers postérieur du corps; l'utérus contient un plus grand nombre d'œufs; le réceptacle séminal est encore dépourvu des spermatozoïdes.

Vers *le septième jour Metagonimus romanicus* devient adulte; il mesure environ 0·95 mm. en longueur et 0·35 mm. en largeur. Tous les organes présentent le volume et la situation de l'adulte. L'utérus est rempli d'œufs. Le réceptacle séminal contient beaucoup de sperme.

La comparaison des caractères morphologiques et de l'évolution de la métacercaire du Metagonimus romanicus et du M. Yokogawai.

En comparant les caractères morphologiques de ces deux métacercaires, on peut voir qu'elles ne diffèrent que par la taille de leurs kystes, qui est plus grande chez *Metagonimus romanicus* (0·18–0·24 mm. en longueur) que chez *M. Yokogawai* (0·12–0·16 mm. de long).

En ce qui concerne le siège de ces deux espèces de métacercaires, je dois attirer l'attention, que j'ai trouvé les métacercaires du *Metagonimus romanicus* dans l'épaisseur des écailles, tandis que Yokogawa prétend avoir trouvé les métacercaires du *Metagonimus Yokogawai* sous les écailles, dans la musculature et dans les nageoires[1].

[1] L'assertion d'Yokogawa, d'après lequel les métacercaires du *M. Yokogawai* se trouveraient sous les écailles, me semble invraisemblable. De même, je crois que les métacercaires, qu'il a vues dans la musculature et dans les nageoires, n'appartiennent pas à *M. Yokogawai*, mais probablement

D'après les recherches d'Yokogawa, il résulte que l'évolution du *Metagonimus Yokogawai* est semblable à celle du *M. romanicus*. Pendant les premiers jours après l'infestation, les jeunes *M. Yokogawai* ne se trouvent pas dans la lumière de l'intestin. C'est seulement en commençant du quatrième ou du cinquième jour qu'ils reviennent dans le canal intestinal pour continuer leur évolution. *Metagonimus Yokogawai* comme *M. romanicus* devient adulte au septième jour[1].

Les recherches d'Yokogawa sont aussi intéressantes parce qu'il a pu suivre sur des coupes le mode de pénétration des métacercaires dans la muqueuse intestinale et leur émigration ultérieure comme jeunes distomes, dans la lumière de l'intestin. En vérité, Yokogawa affirme que dès que ses métacercaires deviennent libres dans le canal intestinal, elles pénétrent dans la muqueuse et s'y engagent jusqu'au muscularis mucosae, où elles se développent pendant 3–5 jours. Ensuite les jeunes trématodes reviennent dans la lumière de l'intestin, mais par un autre chemin que celui suivi pendant la pénétration dans la muqueuse.

Yokogawa, expérimentant principalement sur des souris, a pu recueillir et examiner, grâce, je crois, à la finesse de l'intestin de ces animaux, des exemplaires de *Metagonimus Yokogawai*, âgés de 3, 10, 24, 36 et 48 heures.

Ce mode d'évolution du *Metagonimus Yokogawai* et du *Metagonimus romanicus*, qui probablement est commun chez tous les Heterophyidés, est

à une espèce d'*Apophallus*. A l'appui de cette opinion vient aussi le fait que Katsurada a constaté une pigmentation noire autour des métacercaires du *M. Yokogawai*, parasitant les nageoires des Cyprinidés du Japon, semblable à celle que j'ai trouvée chez les métacercaires d'*Apophallus Mühlingi*, parasitant les nageoires des poissons du Danube.

[1] Qu'il me soit permis de signaler, à cette occasion, quelques erreurs insérées dans les Traités de Parasitologie:

Ainsi l'on dit que *Metagonimus Yokogawai* fait son évolution pendant 15 jours. En réalité *M. Yokogawai* et tous les autres Heterophyidés, dont la période d'évolution est connue (*Heterophyes nocens*, *Metagonimus romanicus* et comme nous allons voir *Apophallus Mühlingi*), deviennent adultes au septième jour après l'infestation. Cela résulte des recherches d'Yokogawa, Onji et Nishio et Ciurea.

De même, ce n'est pas juste que *Clonorchis sinensis* et *Opisthorchis felineus* font leur évolution en 25 jours, mais seulement en 12–15 jours. Cela ressort des observations de Kobayashi et de Ciurea.

Ces erreurs proviennent du fait que quelques auteurs n'ont pas apprécié l'état adulte de ces distomes d'après l'apparition des œufs dans l'utérus—ce qui a lieu plus tôt—mais d'après l'apparition des œufs dans les selles des malades qui a lieu un peu plus tard.

De plus, il ne nous semble pas exact que les œufs typiques du *Metagonimus Yokogawai*, *Clonorchis sinensis* et *Opisthorchis felineus* possèdent un petit point ou un prolongement au pôle non operculé. Excepté Yokogawa, les autres auteurs (Braun, Looss, Kobayashi, Ciurea) n'ont ni décrit, ni figuré ce prolongement chez les œufs typiques de ces trématodes. D'ailleurs, les œufs typiques de tous les Heterophyidés et Opisthorchiidés ne présentent aucun prolongement chez le pôle non operculé.

Ce petit point, ou bouton, s'observe le plus souvent chez les premiers œufs des jeunes distomes et plus rarement chez ceux complètement adultes. Les œufs qui possèdent ce bouton doivent être considérés comme œufs atypiques. Kobayashi a observé des œufs atypiques chez les jeunes *Clonorchis sinensis* et j'ai eu l'occasion de les constater chez beaucoup d'autres trématodes. Les œufs décrits par Yokogawa chez *Metagonimus Yokogawai* ne sont que des œufs atypiques.

important, non seulement au point de vue de la biologie de ces trématodes, mais aussi au point de vue de la pathologie de l'intestin. Les nombreux canalicules que ces distomes creusent dans la muqueuse, pendant leur évolution, peuvent servir comme portes d'entrées pour les différentes infections produites par des protozooaires ou des bactéries pathogènes.

La morphologie de la métacercaire d'Apophallus Mühlingi
(Pl. IV, fig. 13; Pl. V, figs. 14–16).

La métacercaire d'*Apophallus Mühlingi* se trouve enkystée dans la musculature et dans les nageoires des différents poissons de la famille des Cyprinidés, parmi lesquels la brême bordelière (*Blicca björkna*) peut être considérée comme le principal hôte intermédiaire.

Les kystes des métacercaires de la musculature sont elliptiques et mesurent 0·21–0·29 mm. de long et 0·14–0·20 mm. de large. La paroi du kyste est formée de deux membranes: l'une externe fibreuse (0·008–0·026 mm. de grosseur) et l'autre interne hyaline (0·004–0·008 mm. de grosseur). Dans le voisinage des kystes on observe, fréquemment, la présence de petits amas de pigment noir. Habituellement, on rencontre les métacercaires dans les couches superficielles de la musculature et souvent tout près des arêtes. Le plus grand nombre de kystes, que j'ai observé, dans un champ microscopique, fut de sept—une fois j'ai trouvé une de ces métacercaires enkystée dans une arête.

Les métacercaires d'*Apophallus Mühlingi*, enkystées dans les nageoires, siègent principalement à l'intérieur des radies et très rarement dans les espaces interradiaires. Parmi les nageoires, c'est la caudale qui est la plus souvent infestée. J'y ai trouvé jusqu'à 41 métacercaires. Les kystes ont la même forme et presque le même volume (0·20–0·27: 0·14–0·19 mm.) que ceux de la musculature. Le pigment noir est plus abondant autour des kystes de ces métacercaires. La quantité de pigment va augmenter avec l'âge des métacercaires, ainsi il est presque absent autour des plus jeunes et plus abondant autour des plus âgées, où il forme des anneaux plus ou moins complets d'une grosseur de 0·029–0·088 mm. Quelques fois le pigment couvre les kystes de ces métacercaires à peu près complètement comme chez les larves de *Diplostomum cuticula* v. Nordm. (voir Pl. III, fig. 12). A l'œil nu, on peut distinguer les métacercaires d'*Apophallus* dans les nageoires comme des petits anneaux ou points noirs (voir Pl. IV, fig. 13).

Les métacercaires d'*Apophallus*, extraites de leurs kystes, sont peu mobiles; leurs caractères morphologiques sont les suivants: 0·51–0·58 mm. de long et 0·098 mm. de large, cuticule avec des petites écailles; ventouse buccale 0·044 mm. en longueur et 0·048 mm. en largeur; pharynx elliptique 0·028 mm. de long et 0·022 mm. de large, œsophagus s'étendant jusqu'au milieu de la longueur du corps, 0·17 mm. de long; ventouse ventrale à l'intérieur du sinus génital situé dans le plan médian et en arrière du milieu du corps, mesurant 0·032 mm. transversalement. Les ébauches des deux testicules, de l'ovaire et du réceptacle séminal, bien visibles, sont placées: les deux premières sur les côtés de la

vésicule excrétoire et les deux dernières immédiatement au dessus de la vésicule. De même, on aperçoit les deux canalicules excréteurs latéraux de la vésicule excrétoire.

D'après ces caractères on peut voir que les métacercaires d'*Apophallus* diffèrent de ceux du *Metagonimus* principalement par leur taille plus grande et par le sinus génital situé dans le plan médian du corps.

L'évolution de la métacercaire d'Apophallus Mühlingi jusqu'à l'état adulte.

Nous avons suivi l'évolution d'*Apophallus Mühlingi* de la même manière que celle du *Metagonimus romanicus*, avec cette seule différence que j'ai nourri dans ce cas les chiens avec de la musculature et des nageoires infestées de métacercaires d'*Apophallus Mühlingi*, provenant de la brême bordelière (*Blicca björkna*).

(*a*) *L'évolution de la métacercaire d'Apophallus Mühlingi jusqu'au distome fécondé.*

Les métacercaires de ce trématode, mises en liberté dans l'intestin, doivent pénétrer dans l'épaisseur de la muqueuse pour continuer l'évolution, car je n'ai pas pu trouver aucun distome dans le contenu intestinal des chiens sacrifiés 3·24 heures et 3 jours après l'infestation.

(*b*) *L'évolution d'Apophallus Mühlingi après la fécondation* (Pl. V, figs. 17–19).

Le quatrième ou le cinquième jour après l'infestation, les jeunes *Apophallus Mühlingi*, déjà fécondés, font leur apparition dans la lumière de l'intestin. Ils mesurent 0·78 mm. en longueur et 0·20 mm. en largeur. Leur sinus génital siège au milieu de la longueur du corps. Tous les organes génitaux sont relativement développés. La vésicule séminale est remplie de spermatozoïdes; l'utérus contient déjà 6–7 œufs.

Le septième jour Apophallus Mühlingi mesure 1·18 mm. de long et 0·23 mm. de large. Il a augmenté principalement en longueur et c'est la moitié postérieure du corps qui s'est considérablement allongée. A cette âge le sinus génital est placé avant le milieu du corps. Toutes les glandes génitales sont complètement développées. L'utérus contient plusieurs œufs. Le réceptacle séminal est rempli de spermatozoïdes. Ces caractères nous indiquent qu'au septième jour l'*Apophallus Mühlingi* est arrivé à l'état adulte.

Chez le chien, l'habitat principal de ce trématode est le tiers postérieur de l'intestin grêle.

Je voudrais encore ajouter qu'à la suite de mes observations sur l'évolution d'*Echinochasmus perfoliatus* v. Ratz, je peux supposer que non seulement les Heterophyidés, mais aussi les Echinostomidés, accomplissent une partie de

leur évolution dans l'épaisseur de la muqueuse intestinale de leurs hôtes définitifs.

Metorchis oesophagolongus Katsurada n'est qu'un jeune Apophallus Mühlingi (Jägerskiöld).

En 1914, Katsurada a trouvé des jeunes trématodes dans l'intestin grêle d'un chat nourri expérimentalement dans l'Institut f. Schiffs- u. Tropenhygiene de Hambourg, avec deux brêmes (*Abramis brama* (L.)), dont la musculature, les nageoires et les écailles étaient infestées par des métacercaires enkystées, qu'il a nommées "*Cercarien A*." Katsurada croyait que ces trématodes représentent une nouvelle espèce de *Metorchis*, pour laquelle il a proposé le nom de *Metorchis oesophagolongus*.

D'après Katsurada les caractères morphologiques de ce trématode, âgé de sept jours, serait les suivants: Corps en forme de spatule, 0·80 mm. de long et 0·25 mm. de large; cuticule avec des épines? ventouse buccale circulaire 0·072 mm. transversalement; pharynx 0·050: 0·039 mm.; œsophage relativement long ($\frac{1}{3}$ de la longueur du corps); branches intestinales s'étendant jusqu'à l'extrémité postérieure du corps; ventouse ventrale dans le plan médian et au milieu de la longueur du corps (Katsurada n'a pas remarqué que cette ventouse siège à l'intérieur du sinus génital); testicules situés l'un avant l'autre, avec les bords un peu échancrés (probablement à cause de la compression); ovaire au dessus des testicules et dans son voisinage le réceptacle séminal; glandes vitellogènes montant sur les parties latérales du corps jusqu'au niveau de la ventouse ventrale; œufs ovales, avec un appendice en forme d'un crochet ou d'un bouton à leur pôle non operculé, mesurant 0·036 mm. de long et 0·022 mm. de large.

Les "*Cercarien A*" ont été trouvés par Katsurada, non seulement chez la brême, mais aussi chez d'autres Cyprinidés d'Elbe et d'Alster (*Leuciscus rutilus*, *Alburnus lucidus*, *Idus idus* et *Blicca björkna*). Les kystes de ces métacercaires sont elliptiques et mesurent: ceux des écailles 0·25–0·26 mm. de long et 0·17–0·18 mm. de large, et ceux des nageoires 0·21 mm. en longueur et 0·18 mm. en largeur—ces derniers présentant une pigmentation noire autour de leur capsule. Par transparence de la paroi du kyste, formée des deux membranes, on peut distinguer: les épines cuticulaires des métacercaires, les ventouses buccale et ventrale, quelquefois le pharynx, les branches intestinales. La vésicule excrétoire, occupant la plus grande partie de l'extrémité postérieure du corps, est remplie de corpuscules ou sphérules calcaires très réfringentes qui paraissent noires.

De la description et des figures données par Katsurada, on peut voir que *Metorchis oesophagolongus* n'est qu'une jeune *Apophallus Mühlingi*, tandis que les "*Cercarien A*" appartiennent: ceux de la musculature et des nageoires à *Apophallus Mühlingi*, ceux des écailles à *Metagonimus romanicus*.

IV. LA DISTRIBUTION GÉOGRAPHIQUE DES HETEROPHYIDÉS CONNUS JUSQU'À PRÉSENT.

Les différentes espèces de Heterophyidés semblent avoir une distribution géographique plus ou moins limitée à une région quelconque d'un seul continent (en exceptant les cas d'importation). L'affirmation de quelques auteurs, sur la présence de mêmes espèces de Heterophyidés dans des régions tout à fait éloignées (appartenant à différents continents), me paraît résider sur une connaissance incomplète, soit de la morphologie, soit de l'œcologie de ces distomes. D'ailleurs, Looss a signalé qu'il y a des espèces de trématodes qui, quoique identiques au point de vue morphologique, doivent être considérées physiologiquement distinctes si on se base sur l'habitat et la distribution géographique différents.

Voyons maintenant les Heterophyidés des différentes faunes de l'ancien et du nouveau monde:

En Europe la distribution géographique est la suivante: *Cryptocotyle concava* et *C. lingua* dans le Nord; *Cryptocotyle jejuna*, *Apophallus Mühlingi*, *Metagonimus romanicus*, *M. dobrogensis* et *Rossicotrema donicum* dans l'Ouest et dans le centre; *Ascocotyle italica* dans le Sud. Quant aux *Pygidiopsis genata* de *Pelecanus onocrotalus* et *Scaphanocephalus expansus* de *Pandion haliaetus*, je les considère comme des parasites de l'Afrique et dans l'Europe seulement comme temporaires, importés pendant la migration de leurs hôtes. Cela, parce que je n'ai pas pu trouver leurs métacercaires chez nos poissons.

De l'Afrique on ne connaît que les Heterophyidés de l'Egypte: *Ascocotyle coleostoma*, *A. minuta*, *Centrocestus cuspidatus*, *Pygidiopsis genata*, *Scaphanocephalus expansus*, *Heterophyes heterophyes*, *H. fraternus*, *H. pallidus*, *H. dispar*, *H. aequalis* et *H. inops*.

En comparant les Heterophyidés de l'Afrique avec ceux de l'Europe, on peut voir que non seulement les espèces, mais aussi les genres (à l'exception d'*Ascocotyle*) de ces distomes sont différents dans les deux continents.

De l'Asie nous connaissons les Heterophyidés du Japon et de la Chine orientale: *Centrocestus cuspidatus* v. *caninus*, *Metagonimus Yokogawai* et *Heterophyes nocens*[1]. De même on a décrit de la Perse: *Heterophyes persicus*.

Il résulte donc que les genres d'Heterophyidés de l'Asie se trouvent à la fois en Europe et en Afrique.

Dans l'Amérique du Nord, c'est Linton et spécialement Ransom qui dans

[1] Je crois que tous les *Heterophyes* du Japon, décrits comme appartenant à *Heterophyes heterophyes*, ne sont que des *Heterophyes nocens*.

De même, je ne partage pas l'opinion de Lane et de Leiper, d'après lesquels *Heterophyes nocens* serait identique au *Heterophyes heterophyes*. En comparant quelques exemplaires de *Heterophyes nocens*, qui m'ont été envoyés par Cort, avec des spécimens de *Heterophyes heterophyes* que je possède de Looss, j'ai trouvé qu'en dehors des caractères différentiels, mentionnés par Cort et Yokogawa (dimensions du corps, rapport de la grosseur entre les ventouses ventrale et génitale, grosseur des œufs), ces distomes se différencient aussi par la situation de la bifurcation intestinale qui chez *Heterophyes nocens* siège immédiatement au dessus de la ventouse ventrale, tandis que chez *Heterophyes heterophyes* elle est située plus haut.

son "Synopsis of the trematode family *Heterophyidae* with description of a new genus and five new species," nous ont fait connaître les Heterophyidés de la faune des Etats-Unis: *Apophallus brevis*, *Ascocotyle longa*, *A. nana*, *Cotylophalus venustus*, *C. similis* et *Cryptocotyle lingua*.

Au travail de Ransom je dois faire les remarques suivantes:

(*a*) Le genre *Paracoenogonimus* Katsurada doit être exclu de la famille des Heterophyidés, car *Paracoenogonimus ovatus* Katsurada n'est qu'un Holostomidé du genre *Prohemistomum* Odhner, comme je l'ai déjà démontré dans une publication antérieure.

(*b*) Le genre *Scaphanocephalus* Jägerskiöld exclu par Ransom de la famille des Heterophyidés doit être réintégré dans cette famille, car les caractères différentiels, donnés par Ransom, à savoir: taille plus grande, position médiane des testicules, lobulation plus profonde des testicules, de l'ovaire et le volume plus grand de l'utérus, ne nous autorisent pas de déplacer ce genre de la famille des Heterophyidés. D'ailleurs, même Ransom reconnaît que les distomes du genre *Scaphanocephalus* ressemblent aux Heterophyidés par la présence d'une ventouse génitale en relation étroite avec la ventouse ventrale, par la disposition des vitellogènes et par l'absence d'une poche du cirre.

(*c*) Nous savons que chez les espèces d'*Ascocotyle*, appartenant à la faune de l'Afrique et de l'Europe (*A. coleostoma*, *A. minuta* et *A. italica*), la ventouse ventrale siège sur la face ventrale du corps, tandis que chez les *Ascocotyle* de l'Amérique (*A. longa* et *A. nana*) la ventouse ventrale est cachée dans un sinus génital (d'après Ransom). D'ailleurs, j'ai pu me convaincre par des coupes effectuées sur des exemplaires d'*A. longa* que je possède, et qui proviennent du Musée de Washington. Il est donc bien possible qu'il ait échappé aux auteurs qui ont décrit les *Ascocotyle* de l'Afrique et de l'Europe que la ventouse ventrale de ces distomes est située à l'intérieur d'un sinus génital. Autrement, il faudrait créer pour les *Ascocotyle* des Etats-Unis un nouveau genre.

(*d*) Le genre *Cotylophalus* Ransom 1920 est synonyme avec *Rossicotrema* Skrjabin 1919. Conformément à la loi de priorité, on doit donc conserver *Rossicotrema*, et *Cotylophalus* tombe en synonymie. Il résulte que les deux espèces de *Cotylophalus*, décrits par Ransom, doivent être nommés *Rossicotrema venustum* et *R. simile*.

(*e*) D'après mes recherches, le *Cryptocotyle lingua* d'Amérique n'est pas identique à celui de l'Europe. En comparant des spécimens américains du *Cryptocotyle lingua* qui provenaient de *Phoca vitulina* (mis à ma disposition par Ransom) avec des exemplaires européens, provenant de *Larus argentatus* (envoyés par Jägerskiöld et Odhner) et du chien (empruntés par Maplestone), je suis arrivé aux résultats suivants: le *Cryptocotyle lingua* d'Amérique est un peu plus petit (0·55–1·52 mm. de long) que celui d'Europe (0·95–2 mm. de long). L'œsophage est plus long chez le premier (0·121 mm.) que chez le dernier (0·055–0·077 mm.) de sorte que la bifurcation intestinale chez le *Cryptocotyle lingua* américain se trouve à une distance égale de la ventouse buccale et ventrale, tandis que chez le *C. lingua* européen elle est plus rapprochée

de la ventouse buccale. Les glandes vitellogènes chez le premier montent sur les parties latérales du corps jusqu'à une distance égale de la bifurcation de l'intestin et de la ventouse ventrale, tandis que chez le dernier elles montent plus haut et assez souvent jusqu'au niveau de la bifurcation intestinale. Ainsi, je crois que le *C. lingua* d'Amérique représente une nouvelle espèce pour laquelle je propose le nom de *Cryptocotyle americana*.

Comme nous voyons, la faune des Heterophyidés de l'Amérique du Nord, par ses genres, ressemble plus à celle de l'Europe.

De la faune de l'Amérique du Sud, on a décrit l'*Ascocotyle agrense* Travassos. Je ne crois pas que l'Ascocotyle trouvé par Faria au Brésil appartienne à l'*Ascocotyle minuta*.

De l'Australie, on ne connaît que le *Scaphanocephalus australis* Johnston.

V. LES MÊMES ESPÈCES DE TRÉMATODES PEUVENT-ELLES PARASITER LES OISEAUX ET LES MAMMIFÈRES?

A ma connaissance, les distomes suivants ont été mentionnés jusqu'à présent comme parasites des oiseaux et des mammifères[1]: *Ascocotyle minuta, Apophallus Mühlingi, Cryptocotyle lingua* et *C. americana*.

Voyons dans quelles conditions et dans quels hôtes ont été trouvés ces trématodes.

L'*Ascocotyle minuta* a été rencontré plusieurs fois chez les chiens et chez les chats et une seule fois chez le héron cendré (*Ardea cinerea* L.). Dans tous ces cas, les parasites étaient nombreux. Les spécimens des chiens et des chats ne différaient pas de ceux du héron que par le fait qu'ils étaient un peu plus grands.

L'*Apophallus Mühlingi* a été recueilli fréquemment et en plusieurs exemplaires dans l'intestin du *Larus ridibundus* et *L. argentatus cachinnans*. Il a été rencontré une seule fois, en plusieurs exemplaires, chez *Phalacrocorax carbo, Cancroma cochlearis, Pelecanus onocrotalus* et en deux exemplaires seulement chez un *Himantopus himantopus*. Expérimentalement, il a été retrouvé en petit nombre dans l'intestin des chiens nourris avec de la brême bordelière, mais seulement chez ceux sacrifiés entre le 4e et le 15e jour après l'infestation. En général, les exemplaires d'*Apophallus Mühlingi* des oiseaux étaient un peu plus grands que ceux des chiens.

Le *Cryptocotyle lingua* a été récolté assez souvent et en grand nombre chez les mouettes (*Larus argentatus, L. fuscus* et *L. marinus*) et une fois (3 exemplaires) chez le chien. Les spécimens, provenant de mouettes, étaient plus grands que ceux du chien.

[1] Dans *Centralbl. f. Bakt.* Ref. Bd. 74, N. 33–34, 1923, j'ai lu le compte rendu d'un travail de Tanabe: "Studies on the trematode with the fresh water fish as the intermediate host" paru dans le *Japan Med. World*, 1922. Tanabe prétend avoir trouvé un trématode *Stamnosoma armatum* chez les oiseaux et chez le chat au Japon, dont les métacercaires se trouveraient chez les poissons Cyprinides. De même, il soutient qu'il a pu infester expérimentalement avec ce distome le chien, le lapin, le rat, la souris et l'homme (autoinfestation). N'ayant pas de renseignements sur la morphologie et la biologie de *S. armatum*, je ne peux rien affirmer en ce qui concerne ce distome.

Le *Cryptocotyle americana* a été recueilli fréquemment et en nombreux exemplaires dans l'intestin des oiseaux aquatiques (*Larus, Gavia, Podiceps* et *Nycticorax*) et rarement dans l'intestin du chien et de *Phoca vitulina*. Les individus, provenant des oiseaux, différaient de ceux des mammifères seulement par une taille un peu plus grande.

De ce qui précède, on peut voir que l'*Apophallus Mühlingi*, le *Cryptocotyle lingua* et le *C. americana* ont été trouvés plus fréquemment chez les oiseaux que chez les mammifères et que les spécimens provenant des premiers hôtes étaient un peu plus grands que ceux provenant des derniers. Cela s'explique par ce que les oiseaux sont les hôtes naturels de ces distomes, tandis que les mammifères ne sont que des hôtes accidentels et ils n'y peuvent pas trouver des conditions aussi favorables à leur développement que chez les oiseaux.

En me basant sur le fait important, acquis à la suite de mes recherches expérimentales, que l'*Apophallus Mühlingi* ne peut vivre que quelques jours seulement chez le chien, je présume que les autres trématodes des oiseaux se comportent chez les mammifères de la même façon, c'est à dire qu'il ne s'agit dans tous ces cas que d'un *parasitisme passager*. Ainsi, les trématodes des oiseaux, quand ils sont trouvés chez les mammifères, doivent être considérés comme des *parasites égarés, passagers*.

En ce qui concerne les exemplaires d'*Ascocotyle minuta* des chiens, des chats et du héron, en me basant sur le fait assez important que ce distome a été rencontré en grand nombre chez les mammifères ainsi que chez un oiseau, je crois qu'il s'agit de deux espèces d'Ascocotyle, dont l'une parasiterait les chiens et les chats et l'autre le héron. Nous avons à faire donc avec deux espèces identiques au point de vue morphologique, mais distinctes au point de vue physiologique, comme il existe déjà d'autres exemples parmi les distomes de la famille des Opisthorchiidés. En effet, d'après Mühling, le *Metorchis crassiusculus* des oiseaux aquatiques et le *Metorchis albidus* des mammifères ne peuvent pas être déterminés avec précision, sans l'indication des hôtes. De même, Looss affirme qu'*Opisthorchis geminus* des oiseaux de l'Egypte (parmi lesquels *Milvus parasiticus* ne quitte pas l'Egypte) ressemble morphologiquement tellement bien à l'*Opisthorchis felineus* des mammifères carnivores de l'Europe, qu'il n'hésiterait pas d'identifier ces deux espèces, si le fait, de ne pas avoir pu trouver l'*O. felineus* chez les mammifères carnivores de l'Egypte, ne s'y opposait pas. En définitif, je crois, avec Looss, que la question sera éclaircie seulement le jour où l'évolution complète de ces trématodes sera parfaitement connue.

VI. DIVISION DE LA FAMILLE DES HETEROPHYIDÉS EN CINQ SOUS-FAMILLES.

Dans ce qui suit, j'essayerai de diviser la famille des Heterophyidés en cinq sous-familles, en me basant sur l'état de développement et le siège des ventouses ventrale et génitale et sur les rapports existants entre les portions terminales des organes génitaux.

Famille *Heterophyidae*.

(*a*) Sous-famille *Heterophyinae*.

Ventouse ventrale et génitale bien développées et situées sur la face ventrale du corps. Canal éjaculateur et vagin s'unissant à leur terminaison dans un seul canal.

Genre *Heterophyes* Cobbold, 1886.

Espèces: *Heterophyes heterophyes* (v. Siebold), *H. fraternus* Looss, *H. aequalis* Looss, *H. dispar* Looss, *H. inops* Looss, *H. pallidus* Looss, *H. persicus* Braun, et *H. nocens* Onji et Nishio.

(*b*) Sous-famille *Metagoniminae* n. s.-fam.

Ventouse ventrale bien développée et à l'intérieur d'un sinus génital placé du côté droit du corps; ventouse génitale atrophiée, représentée par des papilles situées à l'entrée du sinus. Canal éjaculateur et vagin s'unissant à leur terminaison dans un seul canal.

Genre *Metagonimus* Katsurada, 1913.

Espèces: *Metagonimus Yokogawai* Katsurada, *M. ovatus* Yokogawa, *M. romanicus* (Ciurea) et *M. dobrogensis* (Ciurea).

(*c*) Sous-famille *Centrosestinae*.

Ventouse ventrale faisant saillie plus ou moins à la surface du corps, ou cachée dans un sinus génital; ventouse génitale à l'intérieur du sinus et en voie d'atrophie, représentée par une formation ovalaire très peu musculeuse (ressemblant à un corps lenticulaire) présentant des petits bâtonnets chitineux (s'irradiant en éventail vers la périphérie). Canal éjaculateur et vagin débouchant séparément dans le sinus.

Genre *Centrocestus* Looss, 1899.

Espèces: *Centrocestus cuspidatus* Looss, *C. cuspidatus* v. *caninus* Leiper.

Genre *Ascocotyle* Looss, 1899.

Espèces: *Ascocotyle coleostoma* Looss, *A. minuta* Looss, *A. italica* Aless., *A. agrense* Travassos, *A. longa* Ransom et *A. nana* Ransom. Probablement qu'ici appartienne aussi *Distomum planicolle* Rud.

Genre *Pygidiopsis* Looss, 1907.

Espèce: *Pygidiopsis genata* Looss.

(*d*) Sous-famille *Apophallinae* n. s.-fam.

Ventouse ventrale bien développée et cachée dans un sinus génital; ventouse génitale en partie atrophiée, représentée par deux papilles situées à l'intérieur du sinus. Canal éjaculateur et vagin débouchant séparément dans le sinus génital.

Genre *Apophallus* Lühe, 1909.

Espèces: *Apophallus Mühlingi* (Jägerskiöld) et *A. brevis* Ransom.

Genre *Rossicotrema* Skrjabin, 1919.

Espèces: *Rossicotrema donicum* Skrjabin, *R. venustum* Ransom et *R. simile* Ransom.

(*e*) Sous-famille *Cryptocotylinae*.

Ventouse ventrale et génitale plus ou moins atrophiées et situées à l'intérieur d'un sinus génital. Canal éjaculateur et vagin débouchant séparément dans le sinus.

Genre *Cryptocotyle* Lühe, 1899.

Espèces: *Cryptocotyle concava* (Creplin), *C. lingua* (Creplin), *C. jejuna* Nicoll et *C. americana* Ciurea.

Genre *Scaphanocephalus* Jägerskiöld, 1903.

Espèces: *Scaphanocephalus expansus* (Creplin) et *S. australis* Johnston.

Qu'il me soit permis d'exprimer ici toute ma gratitude à mon ami Monsieur le Docteur D. Ionescu, Directeur des Pêcheries de l'Etat (Braïla), pour l'intérêt qu'il témoigne à toutes mes recherches, en m'envoyant le matériel nécessaire à mes expériences.

De même, je prie mes distingués collègues Messieurs les Professeurs: Cort, Hall, Jägerskiöld, Looss, Maplestone, Odhner et Ransom de recevoir l'expression de mes meilleurs remerciements pour la bienveillance qu'ils ont eu de mettre à ma disposition le matériel de comparaison dont j'ai eu besoin dans ce travail.

Ma très vive reconnaissance à ma femme, Cécile Ciurea, qui m'a toujours secondé dans mes recherches.

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EXPLICATION DES PLANCHES I—V.

Les figures 12 et 13 ont été exécutées d'après nature, les autres ont été dessinées avec la chambre claire; les figures 9, 16 et 15 ont été faites d'après un matériel frais, les autres d'après un matériel conservé dans l'alcool 70 pour cent.

ABRÉVIATIONS USITÉES.

A., arête; *CE.*, canaux excréteurs latéraux; *CJ.*, canal éjaculateur; *G.*, graisse; *GV.*, glandes vitellogènes; *IR.*, membrane interradiaire; *LDC.*, larve de *Diplostomum cuticula* v. Nordmann; *MA.*, métacercaire d'*Apophallus* enkystée (jeune); *MAP.*, métacercaire d'*Apophallus* enkystée avec du pigment noir autour du kyste (plus âgée); *MM.*, métacercaire de *Metagonimus* enkystée; *o.*, ébauche de l'ovaire; *O.*, ovaire; *P.*, pore génital; *PG.*, papilles génitales; *PN.*, pigment noir; *R.*, radie; *rs.*, ébauche de réceptacle séminal; *RS.*, réceptacle séminal; t_1t_2, ébauches de testicules; T_1T_2, testicules; *U.*, utérus; *V.*, vésicule excrétoire; *VB.*, ventouse buccale; *VC.*, vésicule excrétoire remplie de corpuscules calcaires; *VS.*, vésicule séminale; *VV.*, ventouse ventrale.

PLANCHE I.

Fig. 1. *Cryptocotyle jejuna* (Nicoll, 1907) de *Larus argentatus cachinnans* Pall., vu par la face ventrale. ×82.

Fig. 2. *Apophallus Mühlingi* (Jägerskiöld, 1889) de *Larus ridibundus* L., vu par la face ventrale. ×82.

Fig. 3. *Rossicotrema donicum* Skrjabin, 1919, du chien, vu par la face ventrale. ×82.

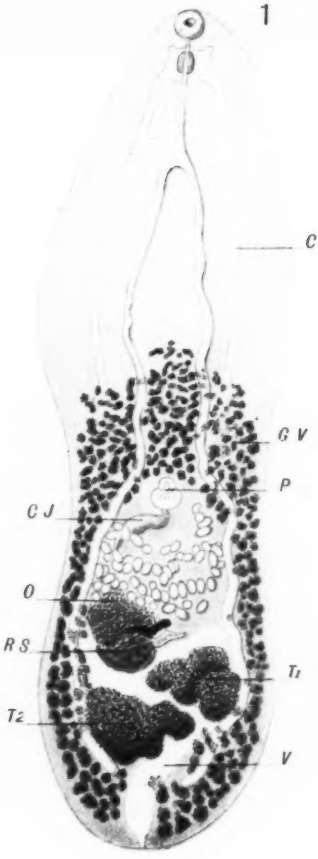
Fig. 4. Œuf du *Rossicotrema donicum*. ×550.

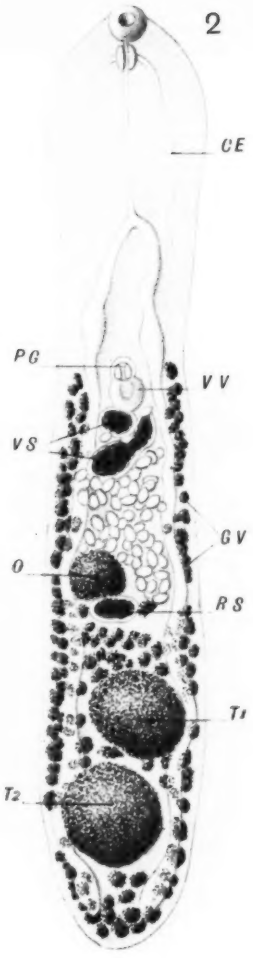
Fig. 5. Métacercaire de *Metagonimus* extraite de son kyste, vue par la face ventrale. ×550.

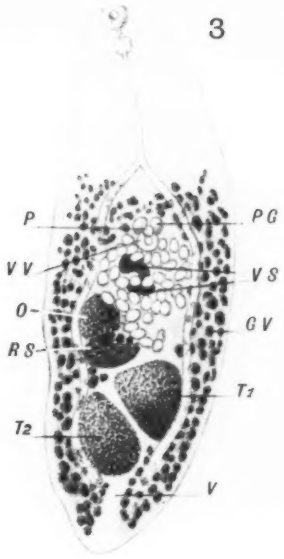
Fig. 6. *Metagonimus romanicus* âgé de quatre jours, vu par la face ventrale. ×82.

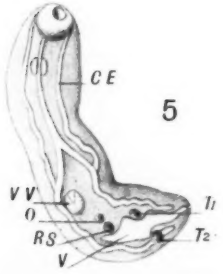
Fig. 7. Œuf d'*Apophallus Mühlingi* du chien. ×550.

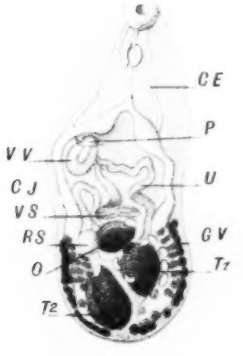
Fig. 8. *Apophallus Mühlingi* (Jägerskiöld, 1889) du chien, vu par la face ventrale. ×82.

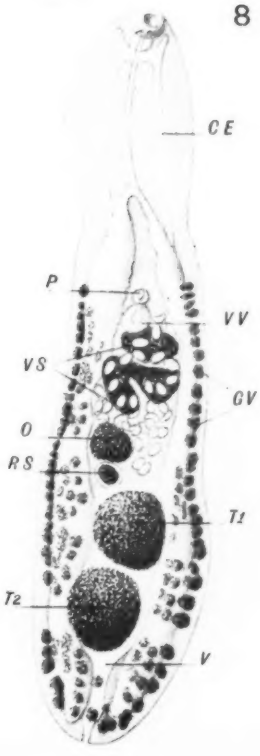












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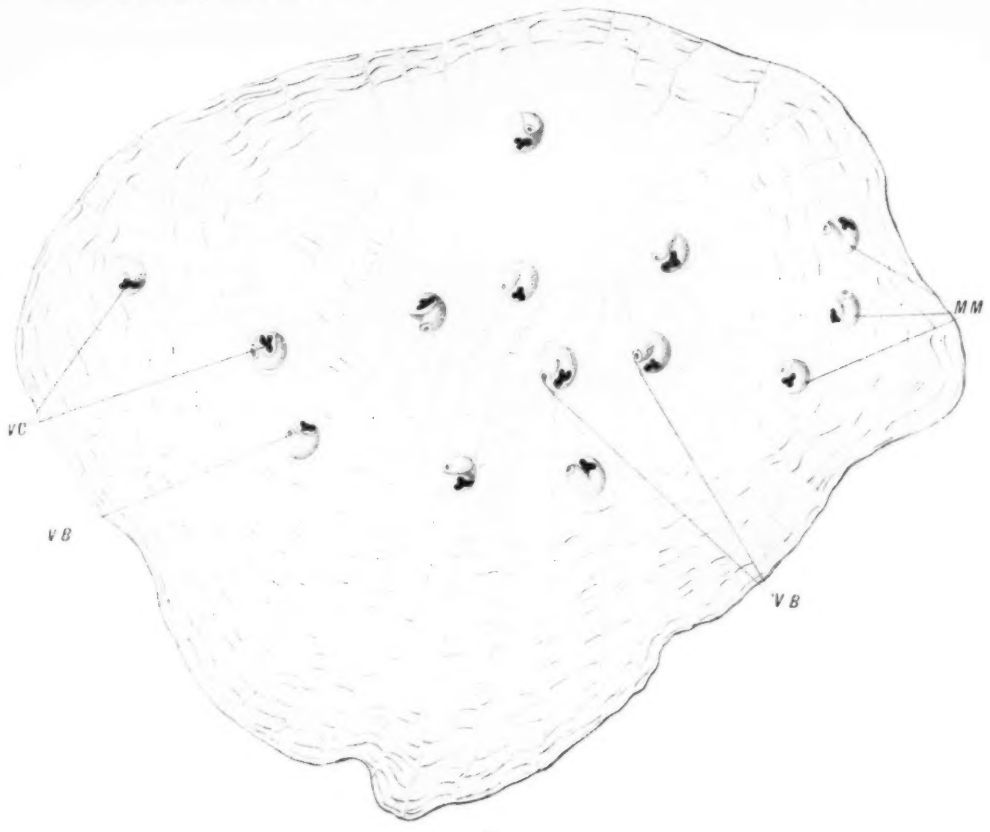

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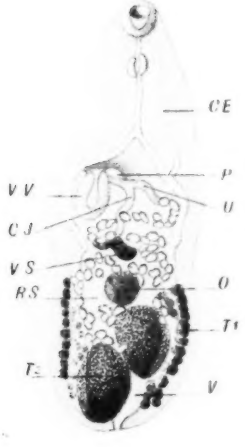

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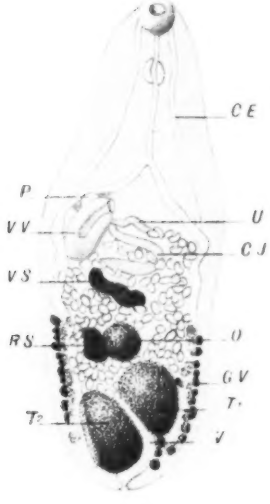

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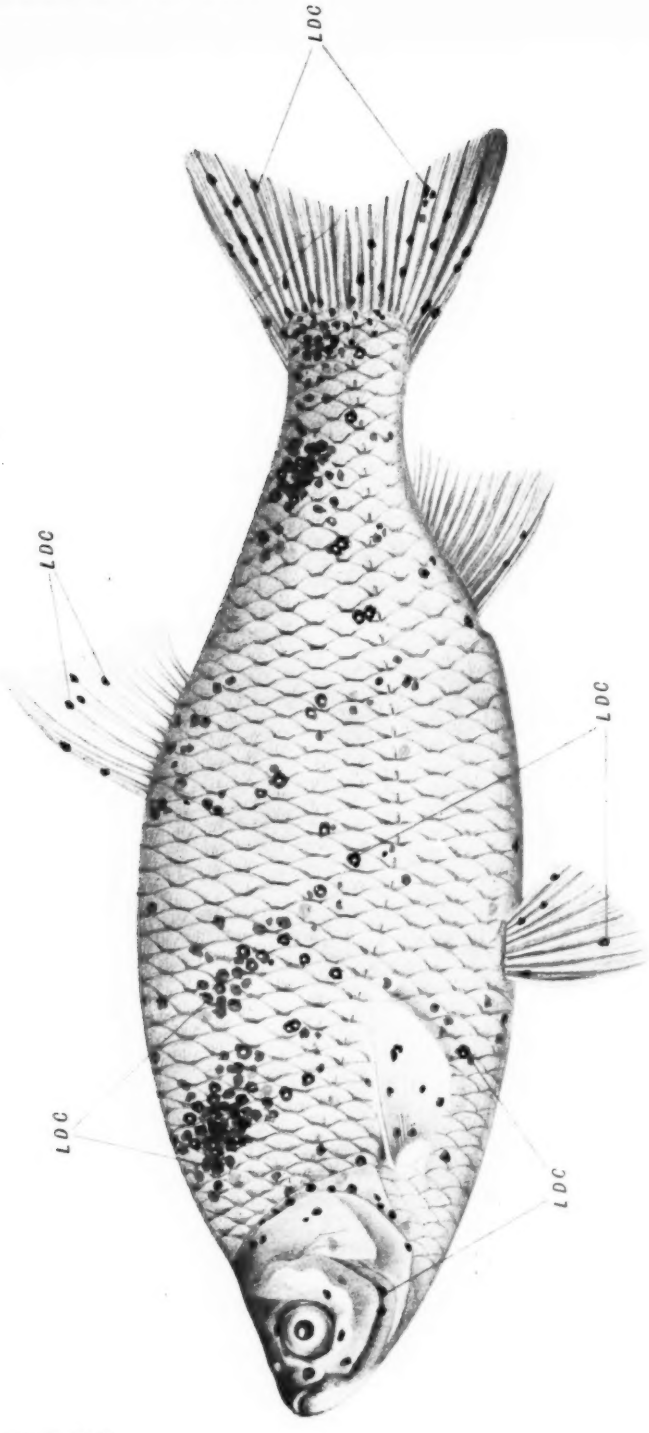

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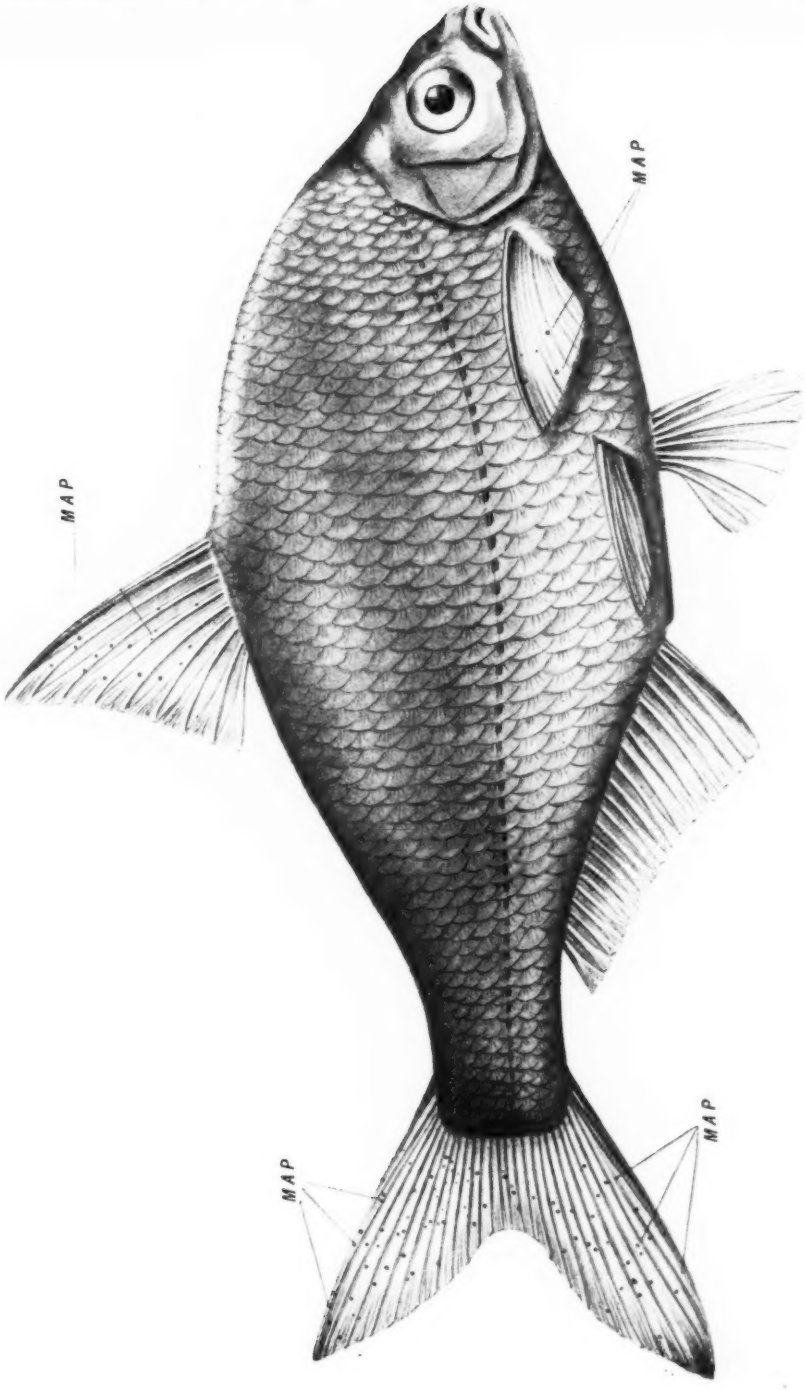

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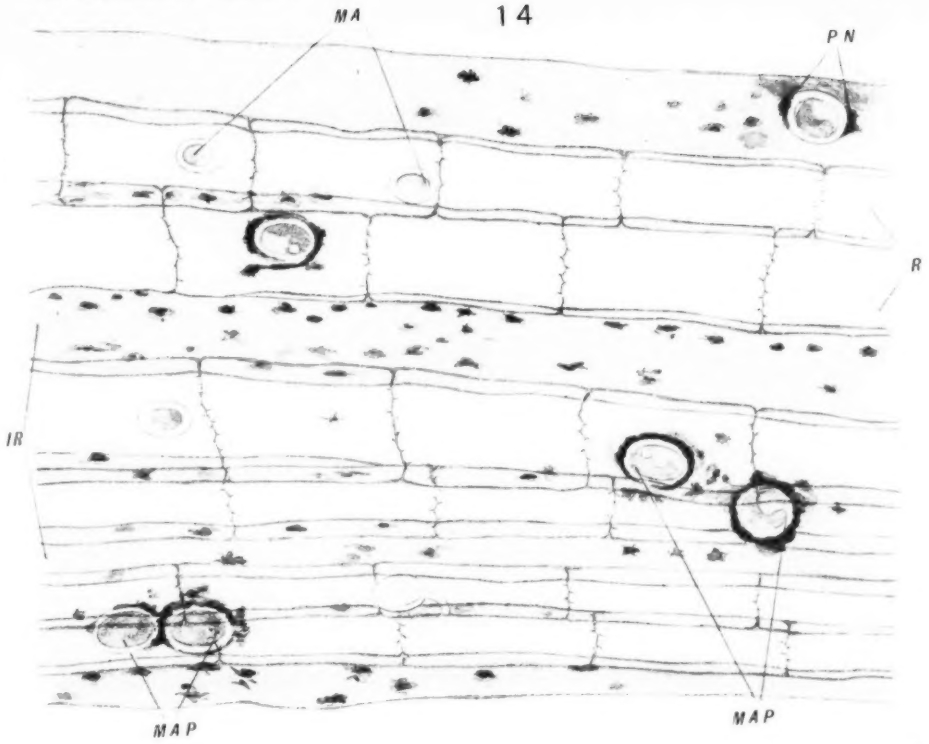

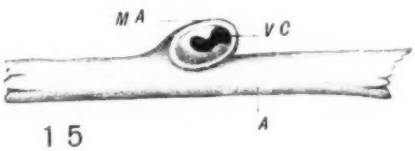

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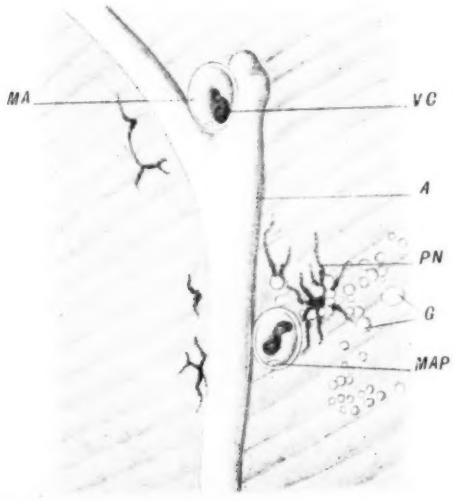

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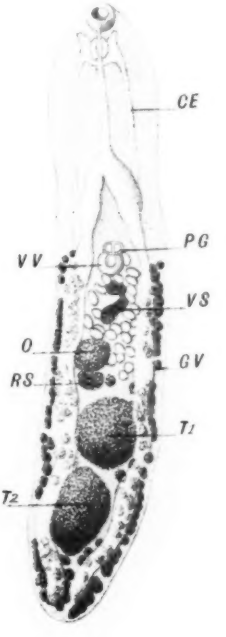

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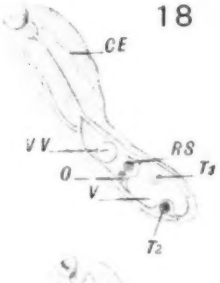

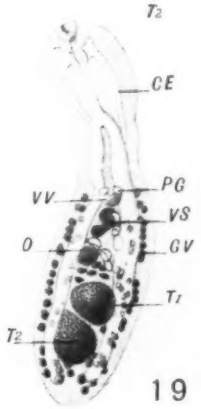

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PLANCHE II.

Fig. 9. Ecaille de la brême bordelière (*Blicca björkna* (L.)) infestée par des métacercaires de *Metagonimus* (enkystées). ×26.
Fig. 10. *Metagonimus romanicus* âgé de cinq jours, vu par la face ventrale. ×82.
Fig. 11. *Metagonimus romanicus* âgé de sept jours, vu par la face ventrale. ×82.

PLANCHE III.

Fig. 12. Rotengle (*Scardinius erythrophthalmus* (L.)) dont la peau et les nageoires sont infestées par des larves de *Diplostomum cuticula* v. Nordmann (enkystées). Grandeur naturelle.

PLANCHE IV.

Fig. 13. Brême bordelière (*Blicca björkna* (L.)) dont les nageoires sont infestées par des méta cercaires d'*Apophallus* (enkystées). Grandeur naturelle.

PLANCHE V.

Fig. 14. Portion de la nageoire caudale de la brême bordelière (*Blicca björkna* (L.)) infestée par des métacercaires d'*Apophallus* (enkystées). ×40.
Fig. 15. Arête de la musculature de la brême bordelière (*Blicca björkna* (L.)) infestée par une métacercaire d'*Apophallus* (enkystée). ×40.
Fig. 16. Musculature de la brême bordelière (*Blicca björkna* (L.)) infestée par des métacercaires d'*Apophallus* (enkystées). ×40.
Fig. 17. *Apophallus Mühlingi* âgé de sept jours, du chien, vu par la face ventrale. ×82.
Fig. 18. Métacercaire d'*Apophallus* extraite de son kyste, vue par la face ventrale. ×550.
Fig. 19. *Apophallus Mühlingi* âgé de cinq jours, du chien, vu par la face ventrale. ×82.

DESCRIPTION OF A NEW GENUS OF LEPODERMATIDAE (TREMATODA) WITH A SYSTEMATIC ESSAY ON THE FAMILY.

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(With 2 Text-figures.)

We had the opportunity of examining about twelve snakes (*Tropidonotus natrix*) all from the same district, and found in almost every case a heavy infection with various Trematodes. In the lungs we found *Saphedra longicollis*, and in the small intestine *Leptophallus nigrovensis* and *Cercorchis nematoides*, together with several specimens of *Odhneria bolognensis* n.g., n.sp. We will discuss the systematic position of this new genus in another part of this paper.

Family	Lepodermatidae Odhner
Genus	*Odhneria* n.gen.
Species	*bolognensis* n.sp.
Host	*Tropidonotus natrix*
Habitat	Pylorus
Locality	Bologna (Italy).

All our observations and measurements were made on the living animal, which was kept alive and examined in Ringer's solution.

On opening the intestine immediately behind the stomach, we found several of these Trematodes firmly fixed by their ventral sucker to the villosity. They were easily seen owing to their size and to their greyish yellow colour, the suckers showing up white.

The total length is very variable, quite young to adult specimens being found together. The average length of adult specimens is 5·95 mm., and the average breadth, measured at the widest part, *i.e.* at the level of the ventral sucker is 1·2 mm.

The posterior end of the body tapers to a blunt point, the anterior end being round. The cuticle is thick, and does not show the slightest trace of spines. The excretory system is characteristic of the Lepodermatidae, *i.e.* a Y-shaped excretory vesicle, with a very long stem, reaching from the excretory pore which is terminal as far as the shell-gland complex, here there is a bifurcation, the two stems being very short and thick, not even reaching beyond the edges of the ventral sucker. This short bifurcation is followed by two tubules, which wind their way forward as far as the anterior level of the pharynx, where they divide up into smaller tubules, two returning into the posterior end of the body

where they ramify, two passing into the anterior end reaching as far as the anterior level of the oral sucker, and two ramifying themselves in front of the ventral sucker. In all our specimens these tubules, as well as the excretory vesicle, were filled with excretory granules, as mentioned by Nicoll in his description of *Dasymetra* n.gen. It is clear that this condition is not a post-mortem transformation, and is generally preserved on fixing.

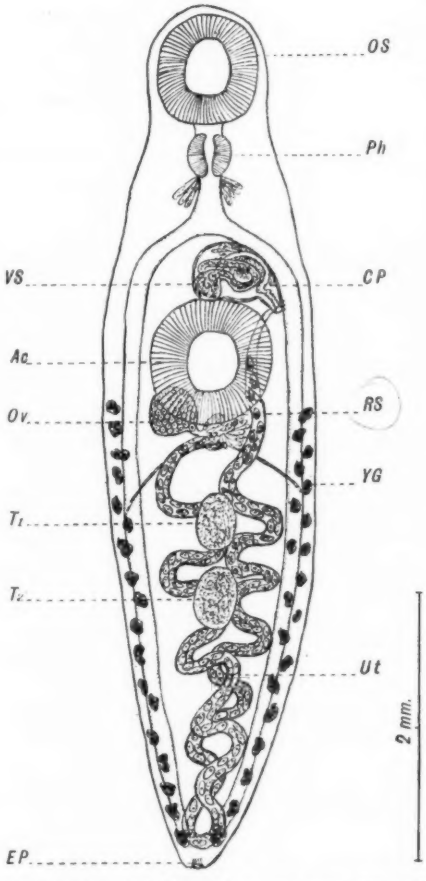

Fig. 1. *Odhneria bolognensis* n.gen., n.sp. *OS.*, oral sucker; *Ph.*, pharynx; *CP.*, cirrus pouch; *VS.*, vesicula seminis; *Ac.*, ventral sucker; *Ov.*, ovary; *RS.*, receptaculum seminis; *YG.*, yolk-gland; T_1T_2, testes; *Ut.*, uterus; *EP.*, excretory pore.

The shape of the excretory vesicle is extremely variable owing to the presence of circular muscles. When it is very full it bulges out behind the ventral sucker, the bifurcations disappear and the whole vesicle has a sack-like appearance. If fixed in the latter state, the systematic position would be erroneous.

The oral sucker is slightly smaller than the ventral sucker, both are spherical, with their openings ventrally. The former measures 0·14 mm. in diameter, the latter 0·07 mm., the ratio being as 1 : 1·4. There is a distinct prepharynx 0·019 mm. in length leading into a well developed pharynx 0·087 mm. in length and 0·076 mm. wide. The oesophagus is short, 0·038 mm. in length, at the base of the pharynx and in the anterior region of the oesophagus there are numerous glands opening into the latter. The two coeca extend into the posterior extremity of the body. It is hard to estimate their exact length for in the same specimen, when alive, the length of the coeca varies, attaining sometimes half the original length, without showing any signs of contraction, at one time one coecum was even longer than the other. It seems clear that this character cannot be regarded either as generic or specific, and should not be considered of systematic importance.

The testes are located in the posterior half of the body, about two-thirds of the total length, their position is median, one close behind the other, but separated by a certain distance. The testes are ellipsoidal, the anterior testis being somewhat smaller, measures 0·48 mm. × 0·4 mm., the posterior testis 0·57 mm. × 0·36 mm. The vasa efferentia lead into a short vas deferens. The cirrus pouch is situated entirely in front of the ventral sucker in the space between the latter and the bifurcation of the coeca, it is half-moon shaped, the genital pore being situated to the left, at the same level as the base of the cirrus pouch. Owing to the position of the genital pore, the whole pouch is displaced to the left. In the specimens fixed by Looss's method, the base of the cirrus pouch is situated behind the ventral sucker owing to the contraction which takes place. The cirrus pouch measures 0·86 mm. in length, and 0·34 mm. in width at its base, it has a thick muscular wall in which the longitudinal muscles predominate. The vesicula seminis is bulbous at the base of the pouch, and continues by a long tube which bends back on itself after having extended forward for about three-quarters of the whole length of the pouch; the pars prostatica is long, the prostate cells occupying most of the available space in the cirrus pouch, and leads into a short ductus ejaculatorius terminated by a fairly long thin inerm penis.

The ovary is spherical, 0·32 mm. in diameter, and is situated to the right behind the ventral sucker. There is a long sinuous Laurer's canal leading into a fairly large receptaculum seminis. The yolk reservoir is median, a little below the receptaculum seminis; two yolk-ducts lead to the yolk-gland, situated laterally and entirely ventral, reaching from the posterior edge of the ventral sucker into the end of the body. The yolk-gland is made up of isolated follicles, and is somewhat sparse. The shell-gland is on the other hand well developed. The uterus passes *behind* the testes into the posterior end of the body, to return by the same way, passing to the left of the ventral sucker, and ending in a vagina opening into a genital atrium. The descending stem of the uterus is situated to the right, and the ascending stem to the left. Both these stems are extremely sinuous. The eggs have a thin yellow shell, and measure 0·095 mm. by 0·057 mm. In the eggs located in the latter portion of the uterus, the miracidia can be distinctly seen moving within the shell.

Diagnosis of the genus Odhneria *mihi. Fairly large* LEPODERMATIDAE, *with a flattened body. Cuticular spines absent. Suckers well developed, oral sucker slightly smaller than ventral sucker. Excretory vesicle typically Y-shaped with short branches. Genital pore situated laterally to the left, genital atrium present. Cirrus pouch well developed, situated in front and to the left of ventral sucker, vesicula seminis coiled, protrudable cirrus present. Testes not lobed situated tandem in posterior half of body. Ovary spherical situated to the right behind ventral sucker. Laurer's canal and receptaculum seminis present. Uterus passes backwards and forwards behind testes and ventral sucker. Yolk-glands sparsely developed, situated laterally and ventral, made up of isolated follicles, extending between ventral sucker and posterior extremity of body. Eggs very numerous, thin*

shelled, 0·095 mm. × 0·057 mm., miracidia developed in the eggs in utero. Parasites in Reptiles. Type: Odhneria bolognensis.

We dedicate this new genus to Prof. Dr Th. Odhner, who has done so much for the study and classification of the digenetic Trematodes.

Systematic discussion. The family LEPODERMATIDAE Odhner is one of the largest, no less than 32 genera, and most heteroclitical of the digenetic Trematodes. It has been the subject of frequent study, and various attempts have been made to sub-divide it into sub-families. Looss considered the family as a sub-family, *Lepodermatinae* Looss = *Plagiorchiinae* Lühe, and in 1902 Pratt created the sub-family *Reniferinae*, for the genera *Renifer* Pratt, *Astiotrema* Looss, *Styphlodora* Looss, *Ochetosoma* Braun, *Oistosomum* Odhner. Finally in 1911 Odhner raised the sub-family *Lepodermatinae* to the rank of family. Since then several new genera have been added, without any attempt being made towards obtaining a natural classification. To our mind, the base of any natural classification must be chosen among the most constant anatomical characters. According to Odhner, of all the systems the excretory system seems to be the most constant. Much light has been thrown on this subject by the work of Cort and Faust, and it would seem that we are at last in the presence of a natural basis for the formation of families for the digenetic Trematodes, the shape of the excretory vesicle serving as a constant familial character. If the excretory systems were better known, it might perhaps be shown that the relationship between the various families can be established by the shape of the excretory vesicle.

Let us consider the excretory system of a Turbellarian of the order *Rhabdocoelida*. Here we find two excretory vesicles, opening by two separate pores; this is the most primitive disposition, also found for the monogenetic Trematodes. If we now suppose that these two vesicles, during their evolution, approach one another so as to finally have one common pore (see diagram, Fig. 2) we obtain the V-shaped vesicle of the digenetic Trematodes. From this point we will have two main branches, the one in which the V-shaped vesicle gradually acquires a stem and forms a Y-shaped vesicle, and the other in which the two branches of the V gradually unite to form the sack-shaped vesicle.

Fig. 2.

Excretory vesicles with side branches would, of course, be considered as derived from the vesicle without the latter.

If we accept this view, we will have a basis for the classification of the digenetic Trematodes, each step in the evolution of the excretory vesicle corresponding to a family.

The excretory vesicle of the Lepodermatidae is of the typical Y-shape,

the stem being much longer than the branches; however, several genera included in this family possess this vesicle, the stem of which presents lateral branches. We consider this character of sufficient importance to justify the formation of a new family for which we propose the name RENIFERIDAE Pratt e.p. Baer. The diagnosis of this new family would be as follows: Fairly large distomes, oval in section. Cuticle provided with spines or smooth. Suckers well developed situated in anterior half of body. Prepharynx, pharynx and oesophagus present, coeca do not reach into posterior extremity of body. Excretory vesicle Y-shaped with lateral branches to the stem. Testes spherical or lobed situated behind ventral sucker, about midway, parallel, one slightly behind the other, or both level. Cirrus pouch well developed, containing a large vesicula seminis, penis inerme. Genital pore situated laterally in front of ventral sucker. Ovary situated to the right behind lower edge of ventral sucker. Laurer's canal present, receptaculum seminis present or absent. Uterus winds its way between the testes into posterior end of body, to return by the same way, opening into a genital atrium. Yolk-glands follicled, fairly well developed, situated laterally. Eggs numerous and small. Found in REPTILES. In this family we include the following genera: *Enodiotrema* Looss, *Renifer* Pratt, *Ochetosoma* Braun, *Lechriorchis* Stafford, *Zeugorchis* Stafford, *Styphlotrema* Odhner and *Pachypsolus* Looss.

We have found it possible to divide the Reniferidae into three sub-families.

1. Sub-family *Enodiotrematinae* mihi.

RENIFERIDAE with a smooth cuticle, characterised by a very short and thick cirrus pouch, nearly totally occupied by the vesicula seminis. The cirrus is extremely reduced and an accessory organ of copulation, in the shape of a spine bearing cul-de-sac, appears. A receptaculum seminis is present.

To the *Enodiotrematinae* belongs only one genus, *Enodiotrema* Looss.

2. Sub-family *Reniferinae* Pratt e.p. Baer.

RENIFERIDAE beset with fine spines, characterised by the position of the genital pore situated to the left, near the outer edge and level with the pharynx, cirrus pouch much lengthened and only reaching as far as the ventral sucker in the genus *Lechriorchis* Staff. Uterus typical of the Reniferidae, *Ochetosoma* alone forming an exception, the general direction being the same, uterus winding its way backwards and forwards. We do not think this anomaly of sufficient importance to exclude this genus from the Reniferinae. To the Reniferinae belong: *Renifer* Pratt, *Ochetosoma* Braun, *Lechriorchis* Stafford and *Zeugorchis* Stafford.

3. Sub-family *Styphlotrematinae* mihi.

RENIFERIDAE beset with spines, characterised by the cirrus pouch which is short and thick, never reaching further back than anterior edge of ovary. Pouch is curled round the ventral sucker, genital pore being situated laterally. Vesicula seminis occupies rear of pouch only. Uterus aberrant from type, resembles that of *Ochetosoma*. Receptaculum seminis present.

To the *Styphlotrematinae* belong *Styphlotrema* Odhner and *Pachypsolus* Looss.

To the Reniferidae belong the two genera *Dasymetra* Nicoll and *Opisthogenes* Nicoll, both having an excretory vesicle with lateral branches; however, their general anatomy varies too much to allow them to be placed in one of the above-mentioned sub-families.

The anatomy of *Opisthogenes* is entirely aberrant from the RENIFERIDAE, yet we consider it a member of that family for the reason mentioned above, and do not agree with Nicoll when he says that his species "is most closely allied to *Opisthogonimus dryochus* West"; the latter genus has a plain Y-shaped excretory vesicle and belongs to the LEPODERMATIDAE.

For the time being we propose to place these two genera in the family RENIFERIDAE, under the title of Genera incerta.

We must now discuss the family LEPODERMATIDAE Odhner e.p. Baer. The diagnosis given by Odhner must be simplified and slightly modified and will be as follows:

Fairly large distomes oval in section; *Ochetosoma* Odhner, alone has a flat body. Cuticle beset with spines or inerm. Suckers fairly wide apart, close to one another in the genus *Saphedra* Looss. Intestine with praepharynx, pharynx, oesophagus, and coeca the length of which is very variable. Excretory vesicle Y-shaped, the stem being much longer than the two branches. Genital pore located before the ventral sucker, and usually somewhat displaced sideways. Cirrus pouch well developed, longitudinal muscles predominating, containing vesicula seminis, pars prostatica and a protrudable penis. This last is lacking in the genera *Astiotrema* Looss and *Glypthelmis* Stafford. Testes spherical or lobed, parallel or tandem. Ovary situated to the right behind ventral sucker. Laurer's canal absent only in the genus *Pneumonoeces* Looss, receptaculum seminis present or absent. Yolk-glands restricted to the sides of body. Uterus passes backwards between testes and returns forwards by the same way. In the genus *Opisthioglyphe* Looss the uterus does not pass beyond the anterior testis, in the genus *Odhneria* mihi the uterus passes behind the testes. The eggs are very numerous and thin shelled. Found in the lungs of Amphibia and Reptiles and in the intestines of Fishes, Amphibia, Reptiles and Birds.

To this family belong the following genera: *Lepoderma* Looss, *Haplometra* Cohn, *Haplometroides* Odhner, *Saphedra* Looss, *Pneumonoeces* Looss, *Pneumobites* Ward, *Cymatocarpus* Looss, *Glossidium* Looss, *Astiotrema* Looss, *Glypthelmis* Stafford, *Opisthioglyphe* Looss, *Opisthogonimus* Lühe, *Pneumatophilus* Odhner, *Odhneria* Baer, *Oistosomum* Odhner, *Leptophyllum* Cohn, *Mediorima* Nicoll, *Aptorchis* Nicoll, *Dolichopera* Nicoll, *Brachycoelium* (Duj.), *Margeana* Cort, and *Leptophallus* Lühe.

We have excluded the genera *Styphlodora* Looss, *Ommatobrephus* Nicoll and *Prymnoprion* Looss, the shape of their excretory vesicle being too aberrant from that of the LEPODERMATIDAE.

On closer examination, we have found it possible to distinguish five subfamilies, based chiefly on the position of the genital pore, on the size, shape and structure of the cirrus pouch and on the general anatomy.

1. Sub-family *Saphedratinae* mihi.

LEPODERMATIDAE, found in lungs of Amphibia and Reptiles. Characterised by the position of the genital pore which opens at the base of pharynx, cirrus pouch very long and thin. Cuticle may be beset with spines. Laurer's canal absent in the genus *Pneumonoeces*. Testes parallel, one slightly in front of the other. *Saphedra* has testes in the tandem position. Yolk-glands scanty in grapelike formation. To the *Saphedratinae* belong *Saphedra* Looss, *Pneumonoeces* Looss, and *Pneumobites* Ward.

2. Sub-family *Lepodermatinae* Looss e.p. Baer.

Typical anatomy of the family, receptaculum seminis only found in *Haplometroides*. Cirrus pouch curled round ventral sucker, genital pore situated slightly to left close to anterior edge of former. Testes spherical, one slightly in front of the other, occupying the tandem position in *Haplometra*. Uterus typical of the LEPODERMATIDAE: in *Haplometra*, however, it passes in front of the testes. Cuticle beset with fine spines. Found in the lungs of Amphibia and in the intestines of Amphibia, Reptiles and Birds.

To the *Lepodermatinae* belong *Lepoderma* Looss, *Haplometra* Cohn and *Haplometroides* Odhner.

3. Sub-family *Cymatocarpinae* mihi.

LEPODERMATIDAE characterised by the fact that the phenomenon of amphitypy is a constant and not an occasional character. The cirrus pouch is well developed, and can reach well behind ventral sucker, as far as anterior edge of ovary. Genital pore is immediately in front of ventral sucker. Vesicula seminis coiled giving the impression of a double vesicula. Testes spherical, right testis ahead of left one. Ovary situated to the left, below ventral sucker. Uterus departs from the usual type, by the fact that it winds its way backwards and forwards, vagina passing to the left behind ventral sucker. Yolk-glands occupy two bands laterally, receptaculum seminis present, except in *Pneumatophilus*. Cuticle beset with spines. Found in the intestines of Fishes and Reptiles. To the *Cymatocarpinae* belong *Cymatocarpus* Looss, *Glossidium* Looss, *Eurymetra* Odhner and *Pneumatophilus* Odhner.

4. Sub-family *Brachycoeliinae* Looss.

LEPODERMATIDAE characterised by spherical testes both at the same level situated about midway, a short thick cirrus pouch containing a well developed vesicula seminis, genital pore almost median, close in front of ventral sucker receptaculum seminis present. Yolk-glands extend from pharynx to testes and no further, dorsally or ventrally they may extend to mid-line of body. The whole posterior half of body is occupied by the coils of the uterus. Cuticle beset with fine spines. Found in the intestine of Amphibia and Reptiles. To the *Brachycoeliinae* belong *Brachycoelium* Looss and *Margeana* Cort.

The genus *Leptophallus* Lühe bears a close resemblance to the two above-named genera, but the presence of a vesicula seminis outside the cirrus pouch and the absence of a receptaculum seminis, also the position of the cirrus

pouch which is curled backwards and totally situated in front of the ventral sucker, do not allow us to place *Leptophallus* in the *Brachycoeliinae*. We propose to attach it to this sub-family under the heading of GENUS INTERMEDIUM.

5. Sub-family *Astiotrematinae* mihi.

LEPODERMATIDAE characterised by a reduced cirrus pouch. Genital pore in front of ventral sucker to the left, penis being no longer protrudable. Testes spherical or lobed, receptaculum seminis present. Cuticle beset with spines. Found in Amphibia and Reptiles.

To the *Astiotrematinae* belong: *Astiotrema* Looss and *Glypthelmis* Stafford. We are now confronted with four genera, belonging without any doubt to the LEPODERMATIDAE, but which differ considerably from one another, and from any of the above mentioned genera. They are *Opisthioglyphe* Looss, *Opisthogonimus* Lühe, *Oistosomum* Odhner and *Odhneria* mihi.

Opisthioglyphe Looss presents the particularity of the testes being close together in the posterior end of body, and of the uterus occupying the space between anterior testis and ventral sucker. The rest of the anatomy is of the Lepodermatidae type. The systematic position of this genus is very problematic. Lühe places it between *Haplometra* and *Lepoderma*, but these last two genera are too closely related to allow them to be separated. The disposition of the uterus and testes being unique among the LEPODERMATIDAE, we think it better for the time being to consider *Opisthioglyphe* as a genus incertum.

We do not agree with Odhner when he places *Opisthogonimus* near to *Styphlotrema* and *Pachypsolus*, these last two being RENIFERIDAE and *Opisthogonimus* LEPODERMATIDAE, in which the cirrus pouch has developed in a most curious manner, so that the genital pore is situated behind the ventral sucker. Rather than make another sub-family *Opisthogonimus* must for the present join *Opisthioglyphe* in the genera incerta.

Oistosomum Odhner is a most curious genus of LEPODERMATIDAE, being morphologically different from any of the other genera. Odhner places it near to *Enodiotrema* Looss on account of the presence of an accessory organ of copulation; however, the excretory vesicle of *Oistosomum* is typically of the LEPODERMATIDAE type, so that this view cannot be held. Until further material is in hand, the systematic position of this genus must be considered as uncertain.

The genus *Odhneria* mihi presents several particularities which render its systematic position most uncertain. The testes are placed as in *Haplometra*, only the uterus is entirely dorsal, and passes behind the testes; the general conformation of the uterus resembles that of *Cymatocarpus*, the ascending coils being separated from the descending coils. The cirrus pouch is situated entirely in front of the ventral sucker, and lies in nearly the same position as in *Leptophallus*. Finally, what distinguishes *Odhneria* from all the other genera of the LEPODERMATIDAE is the precocious development of the eggs, miracidia being seen in the egg *in utero*. This has been mentioned by Nicoll in a description of his genus *Ommatobrephus* n.gen. However, no relationship whatever

exists between these two genera belonging to two distinct families. We consider that *Odhneria* must for the present be left as unique among the LEPODERMATIDAE.

There remain still four genera to be discussed, although they must be placed among the incerta for want of material allowing the excretory system to be worked out. These genera are *Mediorima* Nicoll, *Aptorchis* Nicoll, *Dolichopera* Nicoll and *Leptophyllum* Cohn. The first three cannot as yet be placed, as their excretory system is unknown. Nicoll places them in the LEPODERMATIDAE, where we will leave them for the time being, although the adherence of the genera *Aptorchis* and *Dolichopera* to this family seems to us extremely doubtful.

Leptophyllum Cohn is remarkably aberrant from any of the known LEPODERMATIDAE, the anatomy showing unusual features, such as the yolk-gland being lateral and dorsal. Cohn places this genus near *Enodiotrema*, but this cannot be the case. As Cohn found his material in a snake which had been for 10 years in spirit, this might account to some extent for the cramped up anatomy of *Leptophyllum*. Until fresh material has been examined, the position of this genus must be considered as uncertain.

Before concluding with the list of our two new families, we want to proffer our sincerest thanks to Prof. Dr O. Fuhrmann for his most useful advice, and for placing his library at our disposal, as well as a yet unpublished list of all the Trematode genera.

Family LEPODERMATIDAE Odhner e.p. Baer.

1. Sub-family *Saphedratinae* Baer.
   1. Genus *Saphedra* Looss = *Macrodera* Looss.
   2. Genus *Pneumonoeces* Looss.
   3. Genus *Pneumobites* Ward.
2. Sub-family *Lepodermatinae* Looss e.p. Baer.
   4. Genus *Lepoderma* Looss = *Plagiorchis* Lühe.
   5. Genus *Haplometra* Cohn.
   6. Genus *Haplometroides* Odhner.
3. Sub-family *Cymatocarpinae* Baer.
   7. Genus *Cymatocarpus* Looss.
   8. Genus *Glossidium* Looss.
   9. Genus *Pneumatophilus* Odhner.
   ?10. Genus *Eurymetra* Odhner.
4. Sub-family *Brachycoeliinae* Looss.
   11. Genus *Brachycoelium* Looss.
   12. Genus *Margeana* Cort.
   13. Genus intermedium *Leptophallus* Lühe
5. Sub-family *Astiotrematinae* Baer.
   14. Genus *Astiotrema* Looss.
   15. Genus *Glypthelmis* Stafford.

Genera incerta.

16. *Opisthioglyphe* Looss.
17. *Opisthogonimus* Lühe.
18. *Oistosomum* Odhner.

19. *Odhneria* Baer.
20. *Mediorima* Nicoll.
21. *Aptorchis* Nicoll.
22. *Dolichopera* Nicoll.
23. *Leptophyllum* Cohn.

Family RENIFERIDAE Baer.

1. Sub-family *Enodiotrematinae* Baer.
   1. Genus *Enodiotrema* Looss.
2. Sub-family *Reniferinae* Pratt e.p. Baer.
   2. Genus *Renifer* Pratt.
   3. Genus *Ochetosoma* Braun.
   4. Genus *Lechriorchis* Stafford.
   5. Genus *Zeugorchis* Stafford.
3. Sub-family *Styphlotrematinae* Baer.
   6. Genus *Styphlotrema* Looss.
   7. Genus *Pachypsolus* Looss.

Genera incerta.

8. *Dasymetra* Nicoll.
9. *Opisthogenes* Nicoll.

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DIE GASTROPHILUS-LARVE ALS GASTPARASIT IN DER MENSCHENHAUT[1].

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(Mit 5 Abbildungen.)

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I. GESCHICHTLICHES.

Es ist schon längst die weit verbreitete Hautkrankheit des Menschen bekannt, welche in Russland bildlich als "Wolossatik" bezeichnet wird. Dieser Volksname findet seine Erklärung im Aberglauben der Bauern, welche überzeugt sind, dass ein ins Wasser gefallenes Pferdehaar auflebe (Verwechselung mit dem *Gordius aquaticus*). In solchem Zustande solle es manchmal beim Baden oder Waschen in die Haut des Menschen eindringen, wo es sich bewegt, ein Jucken verursacht und in der Haut eine rötliche, leicht angeschwollene Spur resp. eine mehr oder weniger gewundenen Linie hinterlassen kann. Diese Krankheit wurde beschrieben (1) von Lee, welcher in der Clinical Society of London, 1874, einen Vortrag über einen Fall der Kriechkrankheit (Creeping eruption) gehalten hat, und (2) von Samson, welcher 1895, in *Wratsch* einen Brief über eine neue Hautkrankheit veröffentlicht hat. Auf Samson's Brief folgten bald analoge Mitteilungen Ssokolow (1895), Kuschen (1896), Olissow (1897), Kumberg (1898), Rownitzky (1898), Wostrikow und Bogrow (1909) in Russland und Lee (1884), Malcolm Morris (1896), Neumann (1895), Kaposi (1898), Harlingen (1902), Boas (1907), Fülleborn (1908, 1918), Knowles (1916), León (1914) u. a. in West-Europa und Amerika.

Der Ursprung dieser eigenartigen Krankheit hat das Interesse der Clinical

[1] A short account of this case by the Authors (1922) appeared in *Bull. Soc. Pathol. Exot.* XV. 555–8 (without figures).—ED.

Society of London derart erregt, dass eine spezielle Kommission (W. Howship Dickinson, Tilbury Fox und Dyce Duckworth) beauftragt wurde, ein Stückchen Haut eines Patienten von Lee zu untersuchen. In der Haut wurde kein Parasit vorgefunden. Späterhin (1884) beschrieb Lee wiederum einen analogen Fall und meinte, dass die Krankheit von "an active parasite or animalcule" herrühre.

Bei uns in Russland hat Samson (1895) unabhängig von seinen englischen Kollegen, im *Wratsch* mitgeteilt, dass er bei einer analogen Erkrankung ein Würmchen gefunden hat, welches an eine Fliegenmade erinnert.

Ferner hat Ssokolow (1895: *Wratsch*, p. 1457) über einen Fall berichtet wobei er den Gang eröffnete, den Parasiten extrahierte, und als erster abgebildet hat. Dieser Parasit wurde Prof. Cholodkovsky überwiesen, welcher denselben als Oestriden-Larve bestimmte. T. Portschinsky dagegen rechnet die Larve zur Art *Gastrophilus haemorrhoidalis* oder *G. pecarum* Fb.

Im selben Jahre hat Prof. N. A. Cholodkovsky (1896) eine Bremsenlarve aus der Menschenhaut, aus dem Gouvernement Novgorod, bekommen. Seine Beschreibung dieses Falles erschien im *Wratsch*, die Larve wurde aber später abgebildet (*Lehrb. d. Zool. u. vergl. Anat.* (1905), Fig. 567). Auf diese Weise wurde die wirkliche Ursache der Hautkrankheit festgestellt, welche verschiedene Namen bekommen hat, nämlich "Wolossatik," "Creeping eruption" (Lee), "Larva migrans" (Crocker), "Hyponomoderma" (Kaposi), "Dermamyiasis linearis migrans oestrosa" (Kumberg).

Obgleich die russischen Beobachtungen über "Wolossatik" positive Resultate ergaben und Mitteilungen darüber auch in der ausländischen Presse erschienen sind, wurde in West-Europa die parasitäre Natur dieser Krankheit und die Möglichkeit des Schmarotzens der Gastrophilus-Larve in der Menschenhaut gar nicht anerkannt oder bezweifelt. Braun schreibt, z. B., dass die von Cholodkovsky gegebene Bestimmung der Larve aus der Haut der Patienten von Samson und Ssokolow noch nachzuprüfen sei. Ebenso negativ verhielten sich auch die Dermatologen zum Gedanken von Kaposi, dass die "Creeping disease" durch die Gastrophilus-Larve hervorgerufen werde.

Im Jahre 1907 hat Boas die Gastrophilus-Larve in der Menschenhaut beschrieben und die Identität derselben mit Exemplaren festgestellt, welche aus der Zungenepithel eines Pferdes extrahiert wurden. Seiner Arbeit schreibt er auch in dem Sinne Bedeutung zu, dass der darin geschilderte Fall "der erste ist, in welchem, ausserhalb Russlands, eine Gastrophilus-Larve in der menschlichen Haut wissenschaftlich konstatiert worden ist" (*l.c.* p. 510). Im selben Jahre erschien die vortreffliche Monographie von Portschinsky, welche dem *Gastrophilus intestinalis* im allgemeinen gewidmet ist, einschliesslich seiner pathologischen Bedeutung für den Menschen und die Tiere. Ausserdem gibt Portschinsky eine ausführliche Beschreibung und Abbildungen der Larven des *Gastrophilus intestinalis* und anderer Gastrophilus-Arten, welche aus der menschlichen Haut im Gouvernement Ufa und Novgorod bekommen worden sind (Larven von Cholodkovsky, 1896, beschrieben).

Im Jahre 1908 gibt Cholodkovsky (*Zool. Anzeiger*) einige Mikrophotographien und eine Beschreibung (auf Deutsch) derjenigen Larven, über welche er früher nur in russischer Sprache geschrieben hat; Fülleborn teilt aber einige Fälle des "Hautmaulwurfs" in Afrika mit, indem er sich auf die allgemeine Beschreibung des äusseren Erkrankungsbildes beschränkt, da es ihm nicht gelang, Gastrophilus-Larven zu finden. Das ist kein Wunder, da der Parasit sich in der Sohle einnistete, deren Haut sich durch Grobheit und Dicke auszeichnet. In seiner Arbeit ging Fülleborn auch auf den Bau der Haut in der Stelle des Parasitendurchganges ein. Er begnügte sich zwar mit der Abbildung des horizontalen Schnittes durch den Gang und mit der folgenden Hindeutung: "man sah aber in der dicken Epidermis der Sohle auf den abgetragenen Flachschnitten sehr deutlich den in die Epithelschichten eingegrabenen Parasitengang, der in seinen nicht erweiterten Abschnitten etwa 0·5 mm. breit war" (Fig. 3). Für die Ursache der Erkrankung hält Fülleborn das Schmarotzen "kleiner wandernden Fliegenlarven" (*l.c.* pp. 21, 22).

Wie dem auch sei, war der Skeptizismus der Aerzte gebrochen, und Angaben über den *Gastrophilus* als Parasiten der Menschenhaut, erschienen bereits in Lehrbüchern (Siehe, z. B., E. Brumpt, *Précis de Parasitol.* p. 606, Fig. 454).

Seitdem wurden die Gastrophilus-Larven in der Menschenhaut häufiger vorgefunden, und in den Arbeiten trat das Bestreben zu Tage die Haut in der Umgebung des Gastrophilusganges eingehender zu untersuchen. Eine derartige Untersuchung wurde auch ausgeführt, nämlich von Knowles (1916) und von Fülleborn, in seiner neuen Arbeit unter Mitwirkung von da Rocha Lima (1918), wo eine ausführliche Uebersicht aller der den Hautmaulwurf und den sogenannten Larbisch betreffenden Daten angeführt ist.

Das ist in allgemeinen Grundzügen die Geschichte der "Creeping disease." Dazu kommt nun unserer Fall bei dessen Bearbeitung wir der eingehenden Beschreibung der Larve selbst (öfters von Autoren ignoriert) und der pathologischen Untersuchung der erkrankten Haut besondere Aufmerksamkeit widmen.

II. KLINISCHES.

Unser Patient ist am 22. Juli, 1921, im Gouvernement Orjel erkrankt; in der Haut der inneren Handfläche fühlte er ein Jucken; nach einigen Tagen wurde auf der Haut ein rotes, erhöhtes Streifchen merklich, welches auf den kleinen Finger überging. Das Vorrücken des Streifchens in verschiedenen Richtungen setzte sich bis zum 10. Dez., 1921, fort; darauf wurde es an dessen Ende eröffnet und aus dem Gange wurde der lebende Parasit (also nach einem Aufenthalte von über 5 Monate im Menschen) entfernt und uns zur Untersuchung überwiesen.

III. BESCHREIBUNG DER GASTROPHILUS-LARVE.

Die Larve gehört zu Gattung *Gastrophilus* und zwar wahrscheinlich zur Art *G. haemorrhoidalis*. Lebend untersucht, war sie bogenartig gekrümmt, unbeweglich, ca. 2 mm. an Länge, rein weiss, mit deutlich sichtbare schwarze Dörnchen- und Hakenkränze. Durch die Haut schimmerten die silberfarbenen Tracheen hindurch. Der Larvenkörper besteht aus 13 Ringen.

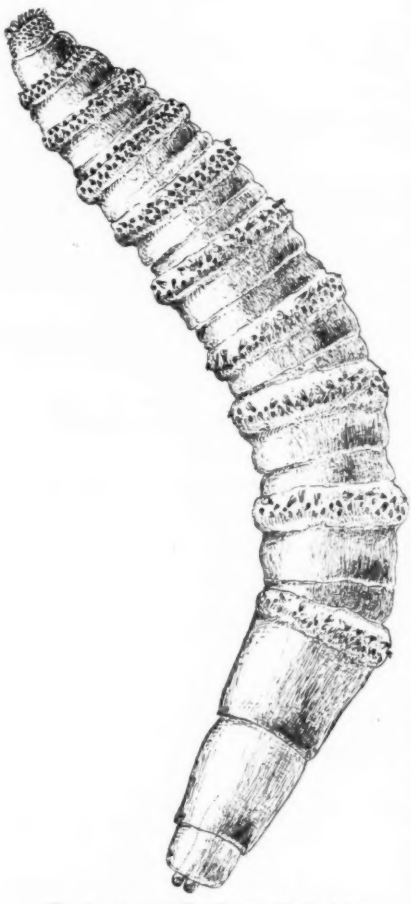


Fig. 1. *Gastrophilus*-Larve (E. P. del.).

Die beigefügten Abbildungen erfordern eine genügende Beschreibung unserer Larve (welche zum 1. Stadium gehört): Fig. 1 repräsentirt unsere Larve in toto, Fig. 2 und 3 das erste resp. Kopfsegment, Fig. 4 die dreireihige Dorne und Hacken der Körpersegmente ((*A*) dorsal resp., (*B*) ventral). Die geschilderten Karaktere werden zur Bestimmung der Art dienen.

IV. DER BAU DES GANGES DER GASTROPHILUS-LARVE IN DER MENSCHENHAUT.

Ein Hautstück des Patienten wurde herausgeschnitten, mit Formalin fixirt, und zu Mikrotomschnitte verwendet. Fig. 5 zeigt, im Querschnitt, zwei Larvengänge welche in der Rete Malpighii liegen. Der Boden des Ganges (*b*), aus flachen, gedrängten Zellen mit pyknotischen Kernen bestehend, liegt in der Nähe des Stratum lucidum. Die Zellen der Seitenwände des Ganges sind weniger zusammengedrückt als denen der Wölbung, sie sind kernlos, undeutlich abgegrenzt, während die benachbarten Zellen degenerirt erscheinen, indem sie aufgetriebene und vakuolisirte Kerne enthalten; stellenweise erscheinen die Kerne als grosse, helle, scharf-begrenzte Bläschen, zum Teil scheinen solche Kerne wie verschmolzen indem sie grössere Blasen bilden. Viele Leukozyten, besonders Eosinophylzellen, befinden sich zwischen den Epithelzellen, besonders der Papillenspitzen. Das Papillengewebe ist blass gefärbt, ödematös, und

dessen Fasern liegen auseinander getrennt. Bei einigen von der Larve kurz vorher verlassenen Gängen ist das Lumen zum Teil mit einer kleinkörnigen Masse aber hauptsächlich mit Leukozyten (viele Eosinophilen) erfüllt.

Die schädliche Wirkung der Larve wird nicht nur auf mechanischem sondern auch auf chemischem Wege ausgeübt.

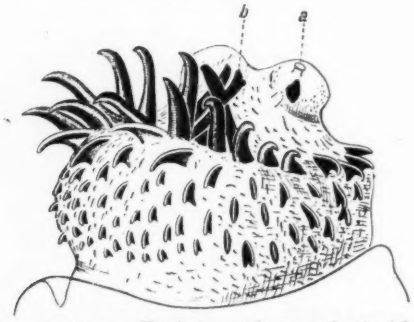


Fig. 2. *Gastrophilus*-Larve, erstes resp. Kopfsegment in ventraler Ansicht, zeigt zwei fühlerähnliche Auswüchse mit (*a*) chitinöse Zylinderchen und (*b*) cephalo-pharyngeale Sclerite, nebst viele Haken (E. P. del.).

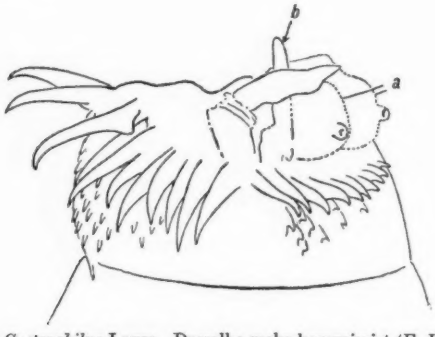


Fig. 3. *Gastrophilus*-Larve. Dasselbe mehr komprimirt (E. P. del.).

V. ZUR BIOLOGIE DER GASTROPHILUS-LARVEN (1. STADIUM).

Die Ernährung der Gastrophilus-Larve geschieht wahrscheinlich auf Kosten der Hautepidermis, in welcher sie sich den Weg durchbohrt. Die Vermutung, dass die Larve mit ihren Kopfhaken und Kiefernentoskleriten Epidermisstücke abreissen und verschlucken solle, ist wahrscheinlich unrichtig. Bekanntlich ernähren sich verschiedene Fliegenlarven, z. B., *Sarcophaga*, *Lucilia*, *Cynomyja* u.a. von der Substanz auf welcher sie leben, nachdem sie dieselbe chemisch umgearbeitet haben. Es handelt sich um periodische Ausscheidung (durch den Mund) einer an proteolitisch-fermentreichen Flüssigkeit, welche das Eiweiss-Substrat peptonisiert. Die verflüssigten Nahrungspartikelchen, welche sich dabei bilden, werden von der Larve aufgenommen.

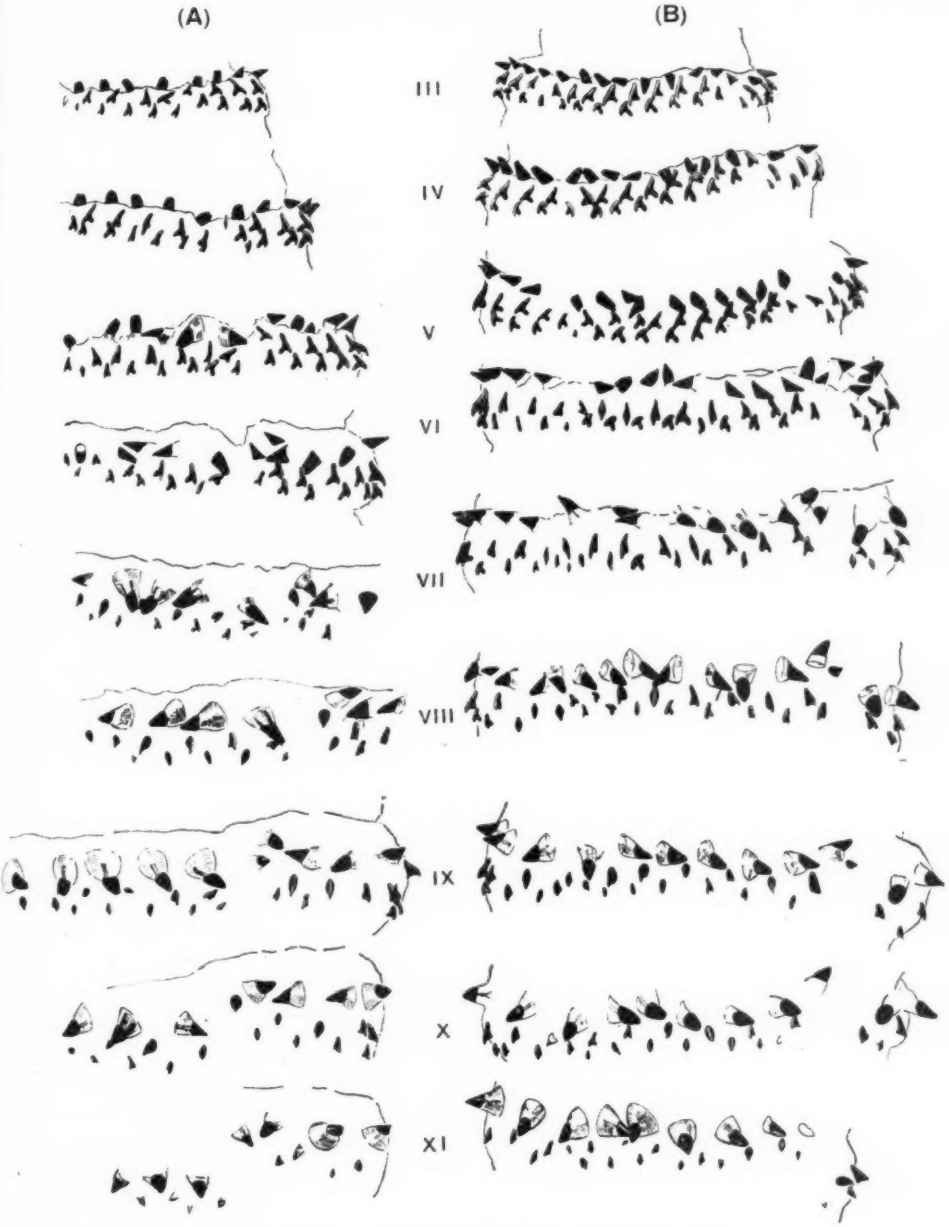



Fig. 4. *Gastrophilus*-Larve. (*A*) Dorsale Haken und Dornen auf Segmente iii–xi.
Gastrophilus-Larve. (*B*) Ventrale Haken und Dornen auf Segmente iii–xi.

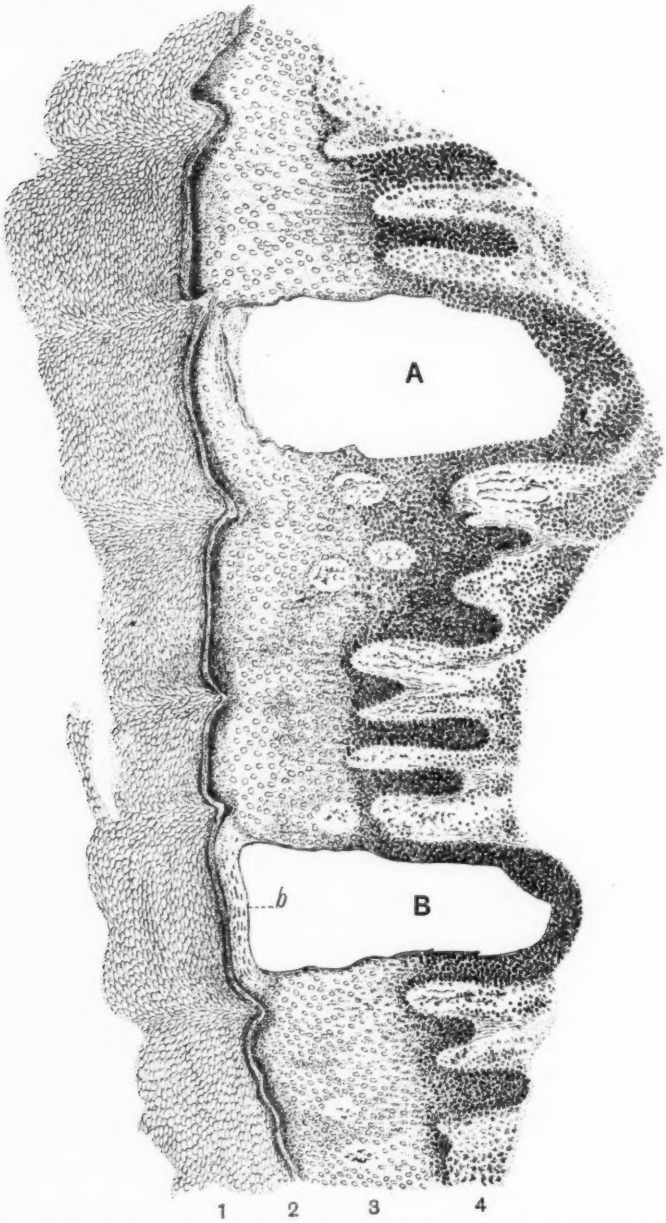


Fig. 5. Schnitt durch die Haut des Patienten: *A* und *B*. Zwei von der *Gastrophilus*-Larve gebohrten Gänge in Querschnitt. 1–4 die Hautschichten (1) corneum, (2) lucidum, (3) malpighii, und (4) coreum. *b* = Boden des Ganges. Haematoxylin-Eosin Färbung. (Nach einer Aquarellzeichnung von P. Wenig.)

Atmung der Gastrophilus-Larve. Die Larve ist mit einem gut entwickelten Tracheennetze versehen; das letztere besitzt einen metapneutischen Charakter. Die Tracheen waren bei unserer Larve mit Luft gefüllt. Leider kann man nicht entscheiden, ob Luft in den Tracheen bereits vorhanden war, als die Larve sich im epidermalen Gange befand, oder ob dieselbe in die Tracheen eindrang, als die Larve aus dem Gange extrahiert wurde.

In der Literatur wird vielfach davon erwähnt, dass aus dem eröffneten Gange der Gastrophilus-Larve eine getrübte seröse Flüssigkeit hervortrat. Es ist also möglich, dass die Larve von dieser Flüssigkeit in situ umgeben ist. Dabei ist aber die Möglichkeit nicht ausgeschlossen, dass die Larve Luft von aussen bekomme. Während die Larve ihren Gang in der Epidermis bohrt, schneidet sie stellenweise die korkzieherartigen Ausführgänge der Schweissdrüse durch. Durch diese Abschnitte der Ausführgänge kann sie nun, vom theoretischen Standpunkt aus, die notwendige Luft erhalten, wenn sie ihre Atmungssyphone an die Öffnung des Ausführganges drückt.

VI. UEBER DIE INFEKTION DES MENSCHEN DURCH DIE GASTROPHILUS-LARVEN UND ÜBER DEN GASTPARASITISMUS DIESER LETZTEREN.

Die Magenbremse zeichnet sich dadurch aus, dass ihre Larven im 2. und 3. Stadium im Pferdemagen leben. Die Frage darüber, wie die Larven in den Magen gelangen, wurde in der Literatur vielfach besprochen. Die Eier werden von der Bremse auf Haare abgelegt. Aus dem Eie schlüpft die Larve im ersten Stadium heraus. N. A. Cholodkovsky hat die Meinung geäussert, dass diese Larven in die Epidermis des Pferdes eindringen, darin wandern und gleichzeitig ein Jucken hervorrufen; das Pferd kratzt die juckenden Stellen der Haut mit den Zähnen, öffnet die Larvengänge und kann dabei die Larven verschlucken. Portschinsky hat diese Theorie ein wenig verändert: er vermutet, dass die in die Epidermis eingedrungenen Larven früher oder später zu Grunde gehen; sie dringen in die Haut hinein, um in derselben einen Reiz hervorzurufen und das Pferd zum Lecken und Kratzen der juckenden Stellen zu veranlassen. Beim Berühren der an den Haaren sitzenden Bremseneier mit der Zunge, öffnen sich die Eier und die daraus hervorkommenden Larven werden vom Pferde leicht verschluckt. Unserer Meinung nach, entspricht dem wirklichen Stande der Dinge diejenige Ansicht, welche die Mitte zwischen diesen beiden Theorien einnimmt. Man kann schwerlich behaupten dass die Larven in den Pferdemagen ausschliesslich aus den Gängen in der Epidermis gelangen können, da es sehr möglich ist, dass beim Zerkratzen der juckenden Stellen die aus den noch nicht geöffneten Eiern ausschlüpfenden Larven gleichzeitig mit den Larven, welche aus den Gängen mit den Zähnen herausgedrückt worden sind, verschluckt werden. Andererseits entbehrt die Behauptung von Portschinsky, dass die in die Haut eingedrungenen Larven zu Grunde gehen müssen und dass "das für diese Larven kritische Moment dann eintreten solle, wenn sie die Länge von 1·5 mm. erreicht haben und sich in ihren schmalen Gängen häuten müssen"—jeglicher

Beweise (*l.c.* p. 32). Unsere Larve hat die Länge von 2 mm. erreicht, sie schritt der Häutung zu und hat dabei ihre Lebenstätigkeit völlig bewahrt: 2 mm. stellen, wie es scheint, kein Grenznorma vor, da Boas in der Zunge des Pferdes Gastrophilus-Larven im ersten Stadium gefunden hat, unter welchen die kleinsten 3 mm. lang waren.

Der Mensch wird durch die Larven der Magenbremse auf zweierlei Art infiziert: (1) die Bremse legt auf die Haare des Menschen Eier ab, aus welchen Larven ausschlüpfen die sich in die Epidermis hineinbohren; (2) der Mensch bekommt die jungen Larven vom Pferde, wenn er das letztere mit feuchten Händen berührt. In unserem Falle fand wahrscheinlich die zweite Infektionsart statt, da man schwerlich vermuten kann, dass die Bremse ihre Eier auf die innere Handfläche des Menschen abgelegt habe und dass die Eier, bei der Arbeit mit dieser Hand, unberührt blieben. Mit dem Pferde dagegen hatte unser Patient während der Ansteckungsperiode zu tun, da er an Landarbeiten teilnahm.

Das Vorfinden der Gastrophilus-Larven in der Menschenhaut muss zu den Erscheinungen des Gastparasitismus gerechnet werden, wenn der Parasit in seinen Wirt nicht gelangt und sich in neuen Bedingungen akklimatisiert und heranwächst, indem er sich auf diese oder jene Weise fühlbar macht.

VII. ÜBER DIE HAUTMYIASEN IM ALLGEMEINEN.

Das Befallen des Menschen oder der Tiere durch die Fliegenlarven hat schon längst die Bezeichnung "Myiasis" bekommen. Die Liste der Fliegen, welche sich daran beteiligen, ist recht umfangreich. Das erklärt sich dadurch, dass ausser den Fliegen, deren Larven nach ihren biologischen Eigenschaften Parasiten vorstellen, auch solche Larven auf den Menschen oder die Tiere gelangen können, welche eine saprophytische Lebensweise führen.

Im Zusammenhang damit kann man vom biologischen Standpunkte aus die *fakultative Myiasis* (wenn die Fliegenlarve zufällig als Parasit auftreten kann) und die *obligatorische Myiasis*, wenn die Larve eine parasitäre Lebensweise führen muss, unterscheiden.

Die *fakultative Myiasis* gehört zur Kategorie der Erscheinungen des Pseudoparasitismus; sie wird gewöhnlich durch die Larven verursacht, die auf Leichen, welche sich zersetzen, und auf faulendem Fleische leben, z. B., *Sarcophaga*, *Lucilia*, *Calliphora* u. viele andere. Für die Larven der genannten Arten stellen Eiterbeulen und Wunden auf lebendigem Körper ein geeignetes Medium für deren Entwicklung vor.

Die Fälle, in welchen der Pseudoparasitismus möglich ist, sind sehr zahlreich, daher werden wir sie nicht weiter betrachten.

Die *obligatorische Myiasis* wird durch Fliegenlarven verursacht, welche sich ausschliesslich der parasitären Lebensweise angepasst haben.

In der Literatur gibt es Versuche, verschiedene Kategorien der Hautmyiasen festzustellen. wobei man von verschiedenen Merkmalen ausgeht.

Indem Joseph die *Myiasis externa dermatosa* berührt, teilt er sie in die *M. externa muscosa* und die *M. externa oestrosa* ein; die erstere wird durch die *Sarcophila wohlfahrtii* verursacht, die zweitere durch die Larven der Bremse *Hypoderma*. Von der durch die Gastrophilus-Larven verursachte Myiasis erwähnt dieser Autor nichts.

Brumpt (1922) unterscheidet im *Précis de Parasitologie* unter "Myiase cutanée":

(*A*) Die *Myiase rampante sous-cutanée* [Creeping disease; nova bolest, pulziasta bolest (Bulgarie), Hautmaulwurf, Larbisch? Larva migrans], in Norvegen und auf den Schottischen Inseln wird sie durch die Larven des 2. und 3. Stadiums von *Hypoderma bovis* hervorgerufen. In Russland und Sibirien wird diese Myiasis durch die Gastrophilus-Larven verursacht.

(*B*) *Myiase sous-cutanée à tumeurs ambulatoires* (Larven von *Hypoderma bovis* und *H. lineata*).

(*C*) *Myiase furonculeuse—Hypoderma diana, H. bovis, Dermatobia.*

Weiter spricht Brumpt von der *Höhlenmyiasis* (Myiase cavitaire), welche folgende Varietäten besitzt:

1°. *Myiase de fosses nasales* oder *nasomyiase.*

2°. *Myiase de conduit auditif* ou *otomyiase* (*Lucilia, Sarcophaga, Calliphora*).

3°. *Myiase oculaire* ou *oculomyiase* (*Oestrus, Rhinoestrus*).

4°. *Myiase simultanée des cavités naturelles.*

5°. *Myiase des plaies* (*Lucilia, Picnosoma, Sarcophaga magnifica*).

6°. *Myiase généralisée.*

Jede Klassifikation der Myiasen ist konventionell; man kann die verschiedenen Myiasenformen von einander nicht scharf abgrenzen, da sie im Laufe der Krankheit ineinander übergehen können; die Höhlenmyiasis, z. B., geht in die Wundmyiasis über u. s. w.

Wir können noch einen Ausgangspunkt für die Gruppierung der Erscheinungen der Hautmyiasen anbieten, nämlich, die primäre Lokalisation der Fliegenlarven im menschlichen Körper. Von diesen Erwägungen ausgehend, unterscheiden wir:

(1) *Die epidermale Myiasis*, wenn sich die Fliegenlarve ausschliesslich in der Epidermistiefe einnistet und aus den Grenzen derselben nicht heraustritt; hierher gehören alle Fälle der Creeping disease, welche durch das Schmarotzen der Gastrophilus-Larven im 1. Stadium in der Epidermis verursacht werden, ebenso wie auch die Larbisch.

Vom pathologisch-anatomischen Standpunkte aus kann man zwei Kategorien der epidermalen Myiasis unterscheiden: (1) die Myiasen, welche sich in dem Stratum Malpighii der Haut, unter dem Stratum lucidum lokalisieren (der von uns beschriebene Fall des Schmarotzens von *Gastrophilus* in der Menschenhaut) und (2) die Myiasen mit der Lokalisation des Ganges über dem Stratum lucidum in der Tiefe der Hornschicht der Epidermis (Knowles, 1916, Fülleborn, 1919 [Larbisch]). Fülleborn denkt, dass der Larbisch auch von parasitärer Natur sein könne, "dass der westafrikanische Larbisch gleich dem Wolossatik

ebenfalls durch eine Gastrophilus-Larve verursacht sein könnte, hat grosse Wahrscheinlichkeit für sich" (*l.c.* pp. 276–7). Eine Entscheidung der Frage von der Ursache des Larbisch wird nur dann möglich sein, wenn man den Parasiten selbst, welcher bis jetzt nicht gefunden wurde, entdeckt. Indem wir die Vermutung von Fülleborn nicht bestreiten, betonen wir doch den Unterschied in der Lage des Ganges des Wolossatiks und des Larbisch in der Epidermistiefe. Die Bedingungen des Lebens in der Hornschicht und im Stratum Malpighii sind freilich ungleich, dass bringt uns auf den Gedanken, dass die oben genannten Kategorien der epidermalen Myiasen durch verschiedene Parasiten verursacht werden. Für die endgültige Behauptung sind neue Daten nicht nur in Bezug auf den Larbisch, sondern auch in Bezug auf den Wolossatik notwendig. Bis jetzt sind nur Einzelfälle beschrieben worden, indessen ist es wichtig aufzuklären, in wiefern die Lokalisation des Ganges über und unter dem Stratum lucidum für diese Kategorie der Erkrankung beständig und typisch ist.

(2) *Die subkutanen Myiasen*, wenn sich die Larven in den Bindegewebsschichten der Haut befinden.

Die subkutane Myiasis verläuft auf verschiedene Weise:

(*a*) Sie kann sich auf die subkutanen Schichten beschränken, wobei sie gutartig verläuft, ohne eine scharfe Reaktion der umgebenden Gewebe zu verursachen. Diese Form nennen wir die *subkutane Myiasis s. strito*. Hierher gehören die *M. sous-cutanée à tumeurs ambulatoires* von Brumpt (*Hypoderma bovis*), ebenfalls wie auch die *M. furonculeuse, M. externa oestrosa*. Sie wird durch die Larven der *Hypoderma diana*, *Dermatobia* [torcelbern, ver macaque] und *Cordylobia* [ver de Cayor, Toumbe, Toumbou] verursacht. Die Hypoderma-Larven dringen auf komplizierte Weise in die subkutane Schicht ein. Beim Verschlucken der jungen Larven, bleiben sie im Oesophagus, dringen unter dessen Schleimhaut ein und gehen durch das Bindegewebe in den cerebrospinalen Kanal über, treten aus ihm hervor und nisten sich in den subkutanen Schichten des Rückenintegu ments ein. Sie wachsen und drücken auf die Epidermis und das von ihnen gebildete Geschwulst öffnet sich schliesslich nach aussen.

Diese Theorie der Entwicklung von *Hypoderma* schwankt jedoch ein wenig im Laufe der letzten Jahre, da einige Naturalisten zu den alten Ansichten zurückkehren, nach welchen die aus dem Ei geschlüpfte Hypoderma-Larve sich aktiv in die Haut des Tieres einbohrt und auf diese Weise in den Körper des Wirtes durch die Epidermis des Hautintegu ments eindringt. Diese Angaben werden durch direkte Beobachtungen bestätigt. Wenn die Sache eine derartige Wendung bekommt, so entsteht die Frage, ob die Hypoderma-Larve eine Zeit lang in der Epidermis lebe, oder ob sie bloss durch die Epidermis in die subkutanen Schichten eindringe? Eine Antwort auf diese Frage gelang es leider bis jetzt noch nicht zu bekommen.

Die Dermatobia-Larven dringen unter die Haut durch die Epidermis mittels der blutsaugenden Moskiten ein, auf welche diese Fliege ihre Eier ablegt.

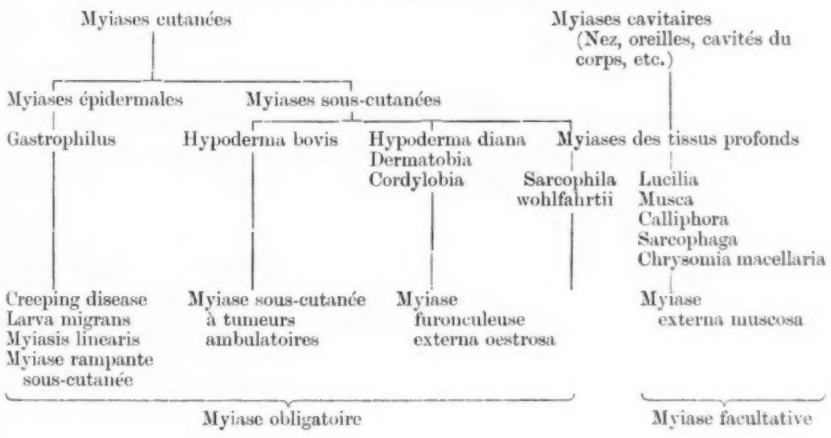
In beiden Fällen lokalisieren sich die Larven im Corium der Haut.

(*b*) Die subkutane Myiasis kann sich in die Tiefe verbreiten und zu einer *Myiasis der tieferen Gewebe* werden, bei welcher die Zerstörung der Weichteile des Körpers sehr umfangreich sein kann; die umgebenden Gewebe reagieren dabei sehr stark, die Lymphgefässe und die Drüsen entzünden sich und es kommt manchmal zur Septichämie. Diese Myiasis wird in obligatorischer Form durch die Larven der *Sarcophila wohlfahrtii*, in der fakultativen Form aber durch Larven anderer Fliegen verursacht.

Die Myiasis der tieferen Gewebe kann auch aus der Höhlenmyiasis entstehen, wenn die Verletzungen bei der letzteren sich als bedeutend erweisen.

Zum Schlusse geben wir eine schematische Klassifikation der Hautmyiasen (zum Teil auf Brumptsche Angaben basirt):

CLASSIFICATION DES MYIASES.



ON A NEW GREGARINE *ANISOLOBUS DACNECOLA* N.G., N.SP., A PARASITE OF *DACNE RUFIFRONS* FABR. (COLEOPTERA).

By MARY VINCENT.

(*From the Molteno Institute for Research in Parasitology, University of Cambridge.*)

(With 3 Text-figures.)

The host of this gregarine is *Dacne rufifrons* Fabr., a small beetle, which is commonly to be found feeding on the polypores which grow on old elm trees in the neighbourhood of Cambridge. Beetles collected in the Autumn, and again in the following Spring, were very heavily parasitized. The beetles live together in small colonies, a habit which greatly increases the chance of infection.

The various stages of the gregarine occur only in the midgut of the host.

The trophozoite (Fig. 1 *A*, *B* and *C*) is chiefly remarkable for the peculiar structure of its organ of attachment. It does not possess a true epimerite, but the anterior end of the protomerite is expanded to form a sucker-like organ by means of which the parasite clings to the intestinal wall. In the youngest forms (Fig. 1 *A*) the margin of the protomerite is nearly straight, but with increasing age the complexity of the sucker increases, and finally a number of irregular lobes are formed (Fig. 1 *B* and *C*).

The body of the trophozoite is short and stout, and the endoplasm is filled with very large granules of paramylon. In the less densely granular specimens the longitudinal striations are plainly visible. The nucleus of the living animal appears as a clear round area: stained preparations show that it contains a single spherical karyosome.

The gregarines associate at a very young stage, and no large unassociated forms were seen. An interesting point to be observed is the difference in shape between the protomerites of primite and satellite. The protomerite of the primite retains its expanded sucker, while the protomerite of the satellite shows no sign of such a structure (Fig. 1 *E* and *F*). The sporonts are intensely granular, and the nucleus is often masked. The total length of the associations varies between 100 and 300μ, and the breadth between 20 and 50μ. The average ratio of width of protomerite to width of deutomerite (in the satellite) is 1 : 1·1; and the ratio of length of protomerite to total length is 1 : 4.

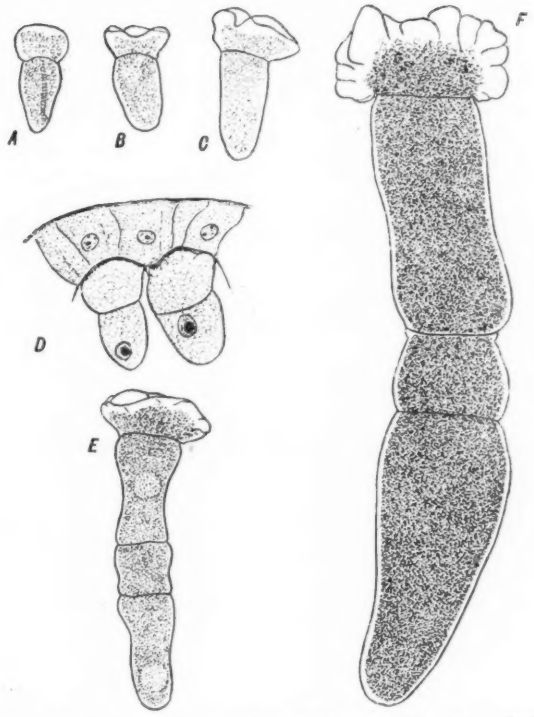


Fig. 1. *A*, *B* and *C*, trophozoites. *D*, section showing trophozoites attached to epithelium. *E* and *F*, sporonts.
A, *B*, *C*, *E* and *F*, ×400. *D*, ×490.

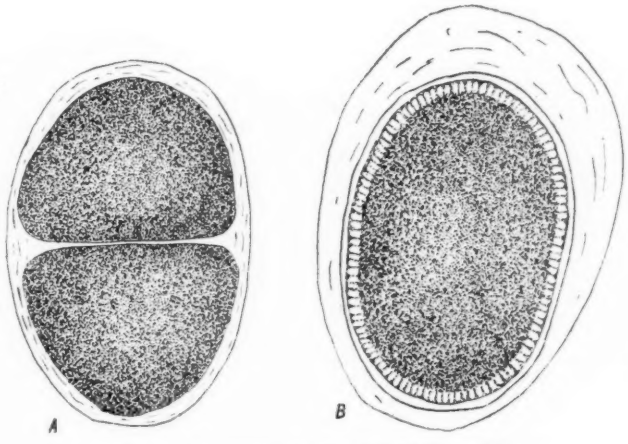


Fig. 2. *A*, young cyst. *B*, a later stage. ×400.

Encystment of the sporonts takes place in the midgut of the host, and the cysts are usually evacuated at an early stage in their development. They are ellipsoidal in shape, and are surrounded by a thick transparent envelope. The average length of the cysts, without envelope, is between 130 and 150μ, and the breadth between 80 and 90μ: the thickness of the envelope is usually 15 to 20μ.

Cysts were collected from the excreta and ripened in water on a slide. At the ordinary temperature of the room they required from two to three days for their complete development. At the end of about twelve hours the gamete nuclei with their surrounding protoplasm have collected at the peri-

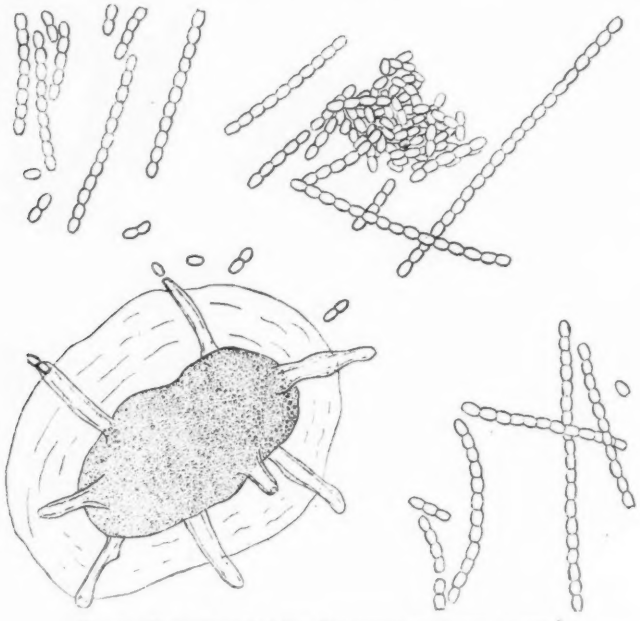


Fig. 3. Ripe cyst which has discharged its spores. ×400.

phery of the cyst where they form a clear ring (Fig. 2 *B*): the formation of the sporoblasts and spores then proceeds rapidly, and the ripe spores are discharged about 48 hours later. The opening of the cysts is effected by means of six or eight sporoducts about 40 or 50μ in length, through which the spores are extruded in long chains (Fig. 3). The spores are barrel shaped and measure 6μ by 4μ.

The systematic position of this gregarine is rather difficult to define. It closely resembles the genus *Gregarina* in three important characters, namely: the association of the sporonts in couples, the dehiscence of the cysts by means of spore ducts, and the barrel shaped spores. The peculiar shaped protomerite

and the absence of a true epimerite, however, prevent its inclusion in this genus which is characterised by a simple globular or cylindrical epimerite.

It is proposed therefore to create a new genus *Anisolobus* and to name the present species *Anisolobus dacnecola*.

Since the genus *Anisolobus* is undoubtedly closely allied to the genus *Gregarina* it would be desirable to include it in the same family, that of the *Gregarinidae*; but unfortunately a simple epimerite is the most important character of this family. The definition of the family quoted from Kamm (1922) is as follows: "Epimerite symmetrical simple. Sporonts solitary or in association. Cysts with or without spore ducts, spores symmetrical (confined to insects with two exceptions, development extra cellular)."

The simple epimerite and the symmetrical spores are the only characters shared in common by each of the genera comprising the family. To extend the definition to include the genus *Anisolobus* would therefore be unsatisfactory; and it seems better, failing further evidence, to leave the position of the genus undefined.

Acknowledgements: I am indebted to Mr A. W. Rymer Roberts who kindly identified the host beetle, and to Dr D. Keilin for his valuable advice.

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(*MS. received for publication* 13. IX. 1923.—Ed.)

ON TWO SPECIES OF CESTODA FROM A MONGOOSE.

By F. J. MEGGITT, M.Sc., Ph.D.,
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(With 2 Text-figures.)

The material described in this paper was obtained from a mongoose (*Herpestes albopunctatus* Hodgson 1853), dead twelve hours when dissected. In the mesentery were numerous larval cestodes and in the intestine approximately fifty adults of another species. The preservation was good. I wish here to acknowledge my indebtedness to Mr G. D. Bhalerao, M.Sc., of this University, for the help given me in the preparation of the specimens.

Oochoristica amphisbeteta n.sp.

(Text-fig. 1, A and B.)

Fifty worms of this species were scattered through the intestine, from the duodenum to the coecum. The attachment was very feeble, a slight pull sufficing to remove the scolex.

Length 15–40 mm., greatest breadth 0·45 mm. Proglottides containing mature genital organs longer than broad. Scolex 0·21 mm. diameter, with four suckers and without rostellum. External segmentation weak, often almost invisible posteriorly. Cuticle unusually thick in proportion to size of proglottis. Musculature weak, consisting of (*a*) an innermost layer of transverse muscles, a few strands thick, (*b*) a layer of longitudinal muscle bundles, each consisting of a few fibres, and (*c*) an outermost layer of scattered longitudinal fibres extending to the sub-cuticula. Calcareous corpuscles few. Dorsal longitudinal excretory vessel absent in gravid proglottides.

Genital organs first appear 5 mm. behind the scolex, the rudiments of cirrus-sac and vagina being the first formed. Genital pores irregularly alternate, with a tendency towards being unilateral, at the junction of the first and second quarters of the proglottis margin. Genital cloaca very deep, extending nearly to longitudinal excretory vessel. Genital ducts pass between longitudinal excretory vessels and dorsal to nerve.

Cirrus-sac large, extending one-third across segment, containing one or two coils of the vas deferens with a mass of prostate cells at its inner end. Cirrus unarmed. Testes 22–24, posterior to ovary, lateral and posterior to vitelline gland, filling the entire hinder portion of the proglottis. Vas deferens forms a mass of coils surrounded by prostate cells.

Ovary immediately posterior to cirrus-sac, median, bilobed, each lobe much subdivided, the division radiating from a common centre, and almost

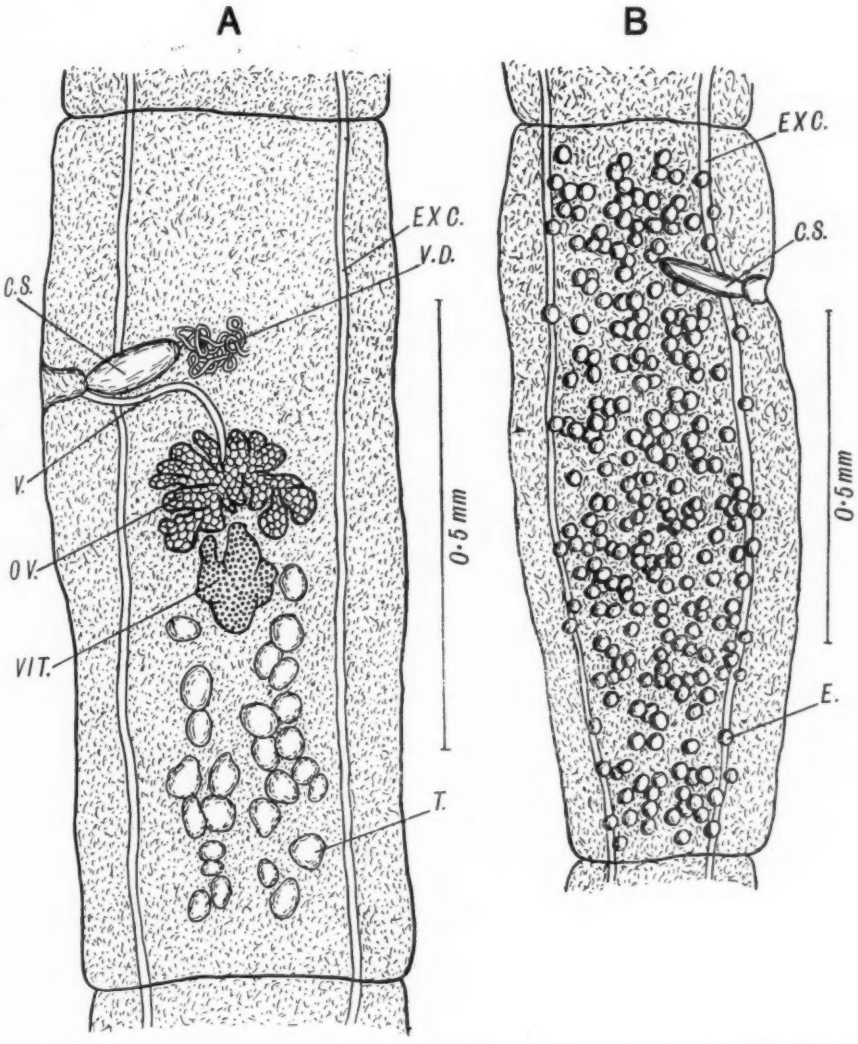

Fig. 1, A. *Oochoristica amphisbeteta* n.sp. Mature proglottis. *C.S.*, cirrus-sac; *EXC.*, longitudinal excretory vessels; *OV.*, ovary; *T.*, testes; *V.*, vagina; *V.D.*, vas deferens; *VIT.*, vitelline gland.
Fig. 1, B. Gravid proglottis. *E.*, egg-capsules.

separated from one another. Vitelline gland reniform, with a deep anterior notch. Receptaculum seminis absent.

Eggs in groups in ovary, later in groups and finally singly in the body parenchyma, filling the gravid proglottis: a few extend laterally beyond the longitudinal excretory vessels. Walls of capsule at first thin and delicate, later thick and staining deeply, agreeing in appearance and structure with similar organs in other cestodes (*e.g. Raillietina echinobothrida*). Baylis (1919, p. 409) in *Oochoristica zonuri*, mentions a membrane surrounding the eggs, in appearance like the one just described, but considers it a third egg-membrane.

This is the first occurrence of a species of *Oochoristica* from the mongoose and the second from a carnivore. Adult parasites previously recorded from the mongoose are *Bothriocephalus folius* (Diesing 1850) and *Diphyllobothrium latum* (Linn. 1735). Upon consulting a key previously given (Meggitt 1920, p. 312) it will be seen that the species approximating most closely to the form just described are *O. tuberculata* (Krabbe 1879) and *O. truncata* (Rudolphi 1819), both from reptiles. The latter may be distinguished by the smaller size of the cirrus-sac and by the vagina opening posteriorly to the cirrus. There appears to be no information of any value existing with regard to the former but as it is a reptilian species of a larger size (length 40–80 mm., diameter 1·5 mm. as compared with 15–40 mm., diameter 1·5 mm.) it is most improbable that it is identical with the worms from the mongoose. For the latter it is therefore necessary to create a new species, for which I propose the name *O. amphisbeteta* n.sp. Co-types have been deposited in the Molteno Institute for Parasitology, Cambridge, British Museum, and Bureau of Animal Industry, Washington.

In recent papers the existence of generic distinctions between *Oochoristica* and *Linstowia* has been queried by Baylis (1919, p. 412) and Beddard (1914). The difference mentioned by the former, in the course of the genital ducts with respect to the longitudinal excretory vessels appears a sufficient distinction: similar differences form the chief distinction between *Progynotaenia* Fuhrmann 1909 and *Proterogynotaenia* Fuhrmann 1911, and between *Anonchotaenia* Cohn 1900 and *Ascometra* Cholodkovsky 1912. Such a character is more definite and less liable to variation than most used for the separation of genera. *Oochoristica* is a genus with a wide range of hosts, containing species from both reptiles and mammals. Below is a list of those recorded.

Oochoristica *spp. found in Mammals.*

O. bivittata (Janicki 1904)	*Didelphys elegans*
	D. murina
O. dasyuri (Beddard 1911)	*Sarcophilus satanicus*
O. didelphydis (Rudolphi 1819)	*Didelphys elegans*
	D. murina
O. erinacei (Meggitt 1920)	*Erinaceus algirus*
	E. sp.
O. incisa (Marotel 1899)	*Meles meles*
O. marmosae (Beddard 1914)	*Didelphys elegans*
O. megastoma (Diesing 1850)	*Alouatta belzebul*
	A. nigra
	Ateles vellerosus

Oochoristica *spp. found in Mammals (cont.).*

	Brachyteles arachnoides
	Callithrix caligata
	C. personata
	C. torquata
	Cebus fatuellus
	C. robustus
	Hapale melanura
	Midas bicolor
O. murina (Zschokke 1904)	*Didelphys elegans*
	D. murina
O. surinamensis (Cohn 1902)	*Tatusia novemcinctus*
O. tetragonocephala (Bremser)	*Myrmecophaga bivittata*
	M. tridactylus
	Tamandua tetradactyla
O. wagneri (Janicki 1904)	*Tamandua tetradactyla*
O. sp. (Janicki 1901)	*Dasypus* sp.
O. sp. (Beddard 1911)	*Tamandua tetradactyla*
O. sp. (Douthitt 1915)	*Geomys bursarius*

Oochoristica *spp. found in Reptiles.*

O. agamae (Baylis 1919)	*Agama* sp.
O. amphisbaena (Rudolphi)	*Amphisbaena alba*
O. crassiceps (Baylis 1920)	*Psammophis subtaeniatus*
O. cryptobothrium (Linstow 1906)	*Chrysopelea ornata*
O. pseudopodis (Krabbe 1879)	*Pseudopus pallasii*
O. rostellata (Zschokke 1905)	*Zamenis viridiflavus*
O. rotundata (Molin 1859)	*Lacerta agilis*
	L. muralis
	L. viridis
O. truncata (Krabbe 1879)	*Agama sanguinolenta*
O. tuberculata (Rudolphi 1819)	*Chrysolamprus ocellatus*
O. zonuri (Baylis 1919)	*Zonurus tropidosternum*
O. sp. (Zschokke 1905)	*Stellio vulgaris*

From this it may be seen that the genus has representatives parasitic in the Marsupialia, Edentata, Insectivora, Rodentia (?), Carnivora and Primates amongst the mammals and in the Lacertilia and Ophidia amongst the reptiles, a distribution which seems to suggest the existence of sub-genera at least. In the present state of our knowledge though, there is no character nor combination of characters separating any group of species from the remainder. There exist isolated characters such as the presence of egg-capsules each containing several eggs in *O. megastoma*, a rudimentary rostellum in *O. cryptobothrium*, and egg-capsules confined to the proglottis margins in *O. bivittata* but they do not agree with the host distribution and only apply to the species in question. A parallel may be found in *Diphyllobothrium* (man, carnivores and seals), *Dipylidium* (man, carnivores, birds), *Hymenolepis* (man, rodents, carnivores, bats, insectivora, marsupials, seals and birds), *Raillietina*, etc. Until further work upon the sub-family Linstowinae as a whole be done this state of affairs cannot be remedied.

Sparganum sp.

(Text-fig. 2, A—C.)

Approximately ten large specimens were found together with numerous smaller ones: both kinds were found in the mesentery near the stomach, the larger also in the body cavity. The latter were free, the smaller enclosed in groups in gelatinous capsules. There was no movement of any kind.

The earliest stage seen (Text-fig. 2, A) consisted of a spherical solid larva with a distinct cuticle like the adult, provided with numerous and very refractive calcareous corpuscles. This was surrounded by several concentric transparent and apparently gelatinous coats, the outer being thinner and less visible than the one immediately preceding it. Altogether there were five of

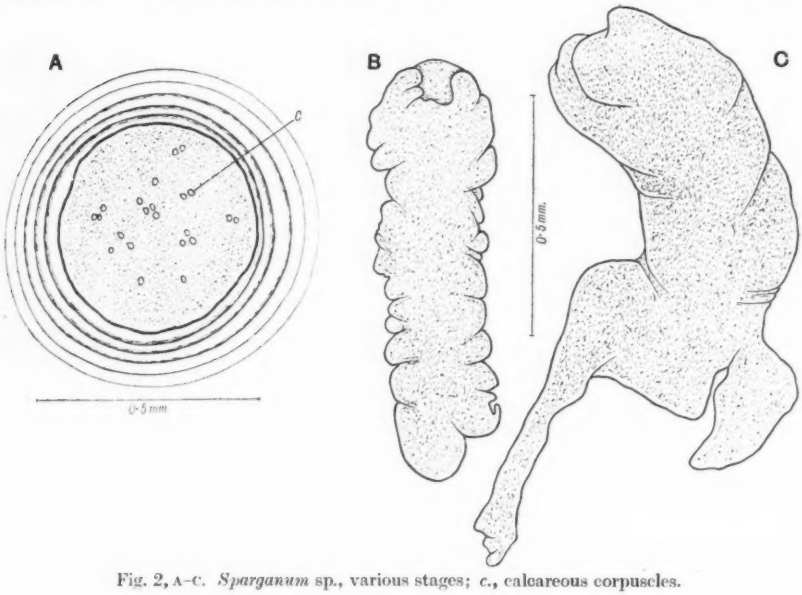

Fig. 2, A–C. *Sparganum* sp., various stages; *c.*, calcareous corpuscles.

these coats. Several of these larval forms were enclosed in a common gelatinous sac with a slight reddish tinge, made from the tissues of the host and attached to the mesentery. No intermediate stages between this and the older specimens could be found.

Amongst the larger forms, the younger (Text-fig. 2, B) were elongated and narrow, with a slight invagination at one end, the older (Text-fig. 2, C) broader and proliferating: all were flattened. There was no trace of suckers, neither internally nor externally, and no segmentation.

In sections, no organs of any kind could be observed. The cuticle was thick, finely striated externally and bounded internally by a distinct sub-cuticula with deeply staining nuclei. No definite muscle layers were present but instead

feeble muscular strands or groups of fibres ran in all directions. The excretory system showed no definite scheme but formed a complex anastomosis of vessels of various sizes. Three types could be distinguished, (*a*) wide, thin-walled vessels corresponding to the ventral excretory trunks of an adult cestode, (*b*) thick-walled, narrow ones corresponding to the dorsal trunks, and (*c*) capillaries. The three types communicated with one another irregularly. The parenchyma was unusually compact, filled with calcareous corpuscles and numerous large, deeply staining nuclei. A central portion was much more diffuse, with few nuclei and no calcareous corpuscles. The excretory vessels showed a tendency to avoid this and concentrate near the margin of the larva.

There were numerous bodies similar to those described by Ijima (1905, p. 15) for *Sparganum prolifer* and by him called "nutritive bodies." In size they varied from 0·05 to 0·3 mm. in diameter. They consisted internally of a mass in appearance like coagulated mucilage. It had no structure and did not appear granular, as stated by Ijima, but flocculent: in the larger forms definite aggregations, with small spaces between them could be observed, in the smaller the contents were more homogeneous. No deeper staining granules similar to those figured by Ijima (Pl. VI, figs. 17 and 20) could be found. Their appearance suggested that the larger bodies consisted of fluid with matter in suspension, the smaller of more solid matter. Each body was surrounded by a thick, deeply staining wall similar to the external cuticle and this again by a ring of fusiform cells with very distinct nuclei and faint bodies, attached to the wall by a narrow strand. Membrane and fusiform cells were invariably present. The bodies were scattered irregularly in the parenchyma, showing a tendency to avoid the centre and congregate at the right and left sides, *i.e.* not on the flattened surfaces. In certain cases each had obviously budded several times and formed either a bunch or a mass of ramifying tubes. Ijima's suggestion that these bodies contain an albuminoid appears to be correct.

This is the first record of a *Sparganum* from the mongoose, the only recorded larval parasites being *Taenia herpestis* (Setti 1893), *Echinococcus granulosus* (Batsch 1786), and *Dithyridum elongatum* (Blumberg 1882) all of which have distinct scoleces and do not proliferate.

The identification of this form presents great difficulties. Most immature cestodes have hooks or suckers by which they may be recognised. In this case all such organs are absent. The only characteristic, the proliferating habit, is shared by such widely different species as *Sparganum prolifer* and *Urocystidium gemmiparum*, the latter being segmented. From its general appearance, the form under discussion is a *Sparganum*. Recent work (Muto and Mihara 1921, Yoshida 1922, Kotlán 1923) has shown that *S. mansoni* and *S. raillieti* are larval stages of *Diphyllobothrium* and that *Sparganum* is probably only a synonym of the latter genus. As far as I am aware, no *Diphyllobothrium* has been recorded from Burma. It is therefore better to leave the specimens unnamed until further investigations have resulted in the discovery of a likely adult. Type specimens in the Molteno Institute for Parasitology, Cambridge.

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(*MS. received for publication* 19. IX. 1923.—Ed.)

THE MALLOPHAGAN FAMILY MENOPONIDAE.

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PART I.

(With 5 Text-figures.)

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A. INTRODUCTORY.

It is perhaps unnecessary to introduce this series of papers with the remark that the chief interest in the study of the Mallophaga centres about the problems associated with their distribution and that these problems are in some measure at least coincident with the problem of the genetic relationship of their hosts. All this has been said very clearly, many times and by various writers. Yet I repeat it again, for it is this interest which is responsible for the papers to follow and it is as a contribution toward the study of these problems that they are intended, notwithstanding the circuitous route that may be followed in arriving at this goal.

Such problems as these are the factors that redeem systematic biology from the dreary round of describing and naming and cataloguing in which some profess to see its only function. And yet it is only by way of this very describing and naming and cataloguing that any light can be obtained by which even to formulate these questions of broader interest. The unfortunate thing is that this basic systematic work is so often hurried over, so often skimped, so often done poorly instead of being done with the same care and skill and patience that is expended upon other fields of endeavour. Of what value are conclusions and theories based primarily upon the results of systematics when the systematics themselves are deficient or perhaps even misleading? Of what value are discussions as to the distribution of species and larger groups when the identifications of the species themselves or the limits of the other groups are open to question? Of what value is a classification that conceals rather than reveals the actual relationships of the forms with which it deals?

All of these queries may justifiably be uttered by students of the Mallophaga. The broader problems upon which the study of this group—and other ectoparasitic groups as well—may throw some light have long been realized, yet the tools that alone are available for clearing the way to these problems have remained strangely dull and inadequate. The systematics of the Mallophaga are in the main little short of chaotic. In but a few groups—and these of but small size—is the work that has been done of a quality even approaching adequacy. The identification of species is in large measure a matter of the application of a theory of probabilities based upon the identity or relationships of the host rather than upon structural criteria of the parasites themselves. The genera are for the most part simply heterogeneous assemblages of superficially similar forms held together by a flimsy structure of artificialities and awaiting a drastic dividing and delimiting to be of any particular significance.

All these conditions are well illustrated in the group of species included in Harrison's admirable catalogue of the Mallophaga[1] under the family *Menoponidae*. The catalogue lists 453 species in this family—nearly one-fourth of all the species of Mallophaga—distributed among twelve genera. There are three genera which are not included in this catalogue and the inclusion of which would change the figures somewhat, but if we take the catalogue as a basis we find 414 of the 453 species comprised within three genera, *Menopon* with 192, *Colpocephalum* with 166, and *Myrsidea* with 56. The largest of the other nine genera contains but eleven species.

There are no subgenera recognized under these large genera, nor are there any keys to the included species. Concealed within them there are unquestionably a considerable series of groups of species, the recognition of which will be necessary in order to bring out the facts of distribution and relationship. That the two largest genera are highly artificial is obvious. In fact, the examination of a series of the species now referred to them will almost leave one with the suspicion that they have been allocated to their respective genera by some one of the many methods in favour among those who follow the Goddess of Chance!

But little seems to have been done in the way of a search for available characters by which either to separate the species or the groups. Such striking and undoubtedly significant structures as the combs on the posterior femora and the ventral side of the abdomen, which occur in a long series of species, have been mentioned in the descriptions of perhaps not more than half a dozen. The only detailed observations appear to be included in a paper by Harrison[2] and another by the present writer[3], with at the most an occasional note by earlier authors.

The purpose of this and the papers to follow is that of attempting the

[1] Harrison, L. (1916). The Genera and Species of Mallophaga. *Parasitology*, IX. 1–155.

[2] Harrison, L. (1915). On a New Family and Five New Genera of Mallophaga. *Parasitology*, VII. 383–406.

[3] Ferris, G. F. (1916). Some Generic Groups in the Mallophagan Family Menoponidae. *Canadian Entomologist*, XLVIII. 301–311.

reorganization of the systematics of this family with a view to bringing out as clearly as may be the facts of relationship as a preliminary to the study of the significance of these facts. The plan that I propose to pursue involves the following steps. First of all the types of the existing genera, or typical species if the actual types be not available, will be described and figured with a view to fixing the starting points for these genera. Succeeding this a review of the species of the family will be carried as far as the available material and the literature will permit and new generic groups will be defined, their types described and figured and species assigned to them as far as possible. The residue of species will then be placed in the existing genera or as unassignable. Subfamilies and tribes will be indicated if they prove desirable, keys to the genera will be given and finally a discussion of the problems of distribution as they appear at the conclusion of this work will be undertaken.

In the figures accompanying these papers I shall endeavour to include as far as practicable every structure to be found on the insects. The actual realization of this ideal is probably—if not certainly—beyond attainment, for scantiness of material will preclude the dissections which are necessary in order to show some structures such as the maxillae, the details of the labium and the actual structure of the male genitalia. Some other structures such as the internal framework of the head will scarcely show to advantage in any but detailed drawings which their probable importance is hardly sufficient to justify. The descriptions will call attention only to the important features that are possibly of generic value and other details may be obtained from the figures. The female alone will be figured in full except perhaps in cases where the male may differ so markedly that it can hardly be visualized by reference to the figures of the female.

B. THE TYPES OF THE EXISTING GENERA.

1. **Menopon gallinae** (Linnaeus).

Fig. 1.

Material examined. Specimens from domestic fowl from the United States and South Africa.

Female (Fig. 1 *A*). A pale species, without dark markings or strongly chitinized regions. *Head* triangular, about three-fifths as long as wide, the greatest width at the posterior border. Lateral margins but very slightly excavated, with a deep slit in front of the eye (Fig. 1 *D*). Antennary fossa deep, open ventrally, the ventral margin, which is the ventral prolongation of the temporal margin, being much surpassed by the dorsal margin. Pharyngeal sclerite and glands strongly developed. Antennae (Fig. 1 *B*) apparently five-segmented, the third segment being extremely minute, the fifth quite long and slender. Labial palpi slender. Gular region (Fig. 1 *E*) with a faintly chitinized plate.

Prothorax with acute wings, the lateral and posterior margins smoothly confluent and forming an arc of a circle. *Mesothorax* much reduced, the notum

being scarcely indicated, the sternum with a faintly chitinized area which bears several quite long setae. *Metathorax* narrow and with its straight sides strongly divergent, its posterior margin nearly straight, the sternum faintly chitinized and bearing several setae. *Legs* of ordinary form, the coxae small,

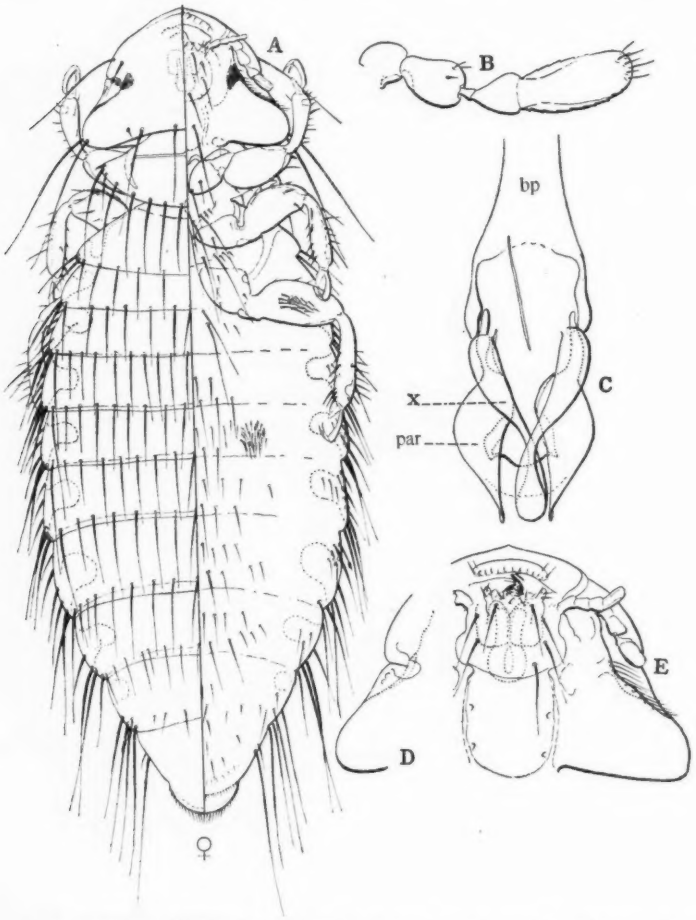

Fig. 1. *Menopon gallinae* (Linnaeus). *A*, female; *B*, antenna; *C*, genitalia of male; *D*, outline of dorsal aspect of lateral margin of head; *E*, portion of ventral aspect of head.

the femora of the anterior pair not at all enlarged, the femora of the third pair with a very distinct brush of 15 to 20 closely set small setae on the ventral side.

Abdomen elongate, tapering, with the tergal and sternal plates extremely weakly chitinized, the sternal plates apparently almost membranous. There

are no visibly differentiated pleural plates, but there is a rather conspicuous internal chitinous pleural thickening on each segment. Tergal plates with but a single transverse row of setae. Sternites with two partial transverse rows and with a pair of conspicuous little brushes of small setae on the fourth segment. Lateral margins of the segments with several long, stout setae. Apex of the abdomen terminating in a rounded dorsal plate and a shorter ventral plate, each of which is fringed by small setae. There are no vestiges of gonapods.

Male. In general appearance practically identical with the female except that the abdomen is slightly less tapering and terminates in a single rounded plate which bears four long setae. Distribution of setae on the abdomen essentially as in the female.

Genitalia (Fig. 1 *C*) very small. I am unable to homologize the parts except for the small, indistinct basal plate (*bp*) and what are apparently the parameres (*par*). Articulating with the tips of the basal plate is a peculiar piece (*x*) which has the appearance of a V the apex of which has been given a quarter turn.

2. **Colpocephalum zebra** Nitzsch.

Fig. 2.

Material examined. A male and a female from the type host, *Ciconia alba*, Ain, France, received through the kindness of Professor J. Pelosse of the Faculty of Sciences of Lyons.

Female (Fig. 2 *A*). A very elongate form, with very conspicuous markings on the head. *Head* slightly wider than long, the greatest width at a point just behind the eyes, the anterior margin rounded, the lateral margins (Fig. 2 *F*) somewhat excavated and with a deep notch just in front of the eye, the temporal margins strongly convergent. Framework of the head very heavily chitinized and forming conspicuous blotches, there being such a blotch about the base of the lateral notch and a pair on the posterior border of the head. These areas appear to extend, at least in part, entirely through the head from dorsal to ventral side. Connecting the two occipital areas is a transverse dorsal band and a fainter band connects these areas with those at the lateral notch. On the ventral side of the head (Fig. 2 *G*) just in front of the antenna is a small, more weakly chitinized area.

Pharyngeal sclerite and glands present. Antennary fossa shallow, owing to the excavation of the side of the head, the ventral and dorsal borders coinciding except about the base of the antenna where the dorsal exceeds the ventral. Antennae (Fig. 2 *D*) with the terminal segment rather short. Labial palpi slender. Gular region with a faintly chitinized plate.

Prothorax with acute wings, the lateral margins practically confluent with the posterior margin and strongly convergent. *Mesothorax* much reduced, the notum consisting merely of a narrow, chitinized band. *Metathorax* with the lateral margins strongly divergent, the posterior margin nearly straight, the sternum weakly chitinized and bearing a few small setae. *Legs* of ordinary

form, the anterior femora not expanded, the posterior femora with a series of combs of setae on the ventral side. These combs (Fig. 2 *B*) are disposed in

Fig. 2. *Colpocephalum zebra* Nitzsch. *A*, female; *B*, combs of posterior femur; *C*, combs of third sternite; *D*, antenna; *E*, genitalia of male; *F*, outline of dorsal aspect of lateral margin of head; *G*, portion of ventral aspect of head.

four transverse rows, the proximal row with two or three setae, the second with ten or twelve, the last two with fourteen or fifteen.

Abdomen elongate and slender, the tergites strongly chitinized, the sternites very weakly so. Tergites of the third to ninth segments divided longitudinally

into three distinct areas, the median area being about half as long as the others. All the tergites with two transverse rows of small setae. Sternites with numerous irregularly disposed small setae and on the third segment two groups of combs. These combs (Fig. 2 *C*) are set on a slight diagonal in the posterior lateral angles of the sternite, there being two rows. Pleurites distinct but small, all bearing several slender setae. Spiracles present on the third to eighth segments, very small, borne at the lateral margin of the tergites. Apex of the abdomen with a rounded dorsal plate and a shorter ventral plate, both fringed with numerous short setae. Gonapods entirely obsolete.

Male. In general characters practically like the female except that the body is shorter and broader and the tergites are not divided. The distribution of the setae is practically as in the female.

Genitalia (Fig. 2 *E*) with the basal plate (*bp*) very long and slender, strongly expanded at the apex where it articulates with a complex of structures that seem to be formed from the walls of the preputial sac. I am unable to identify any parameres and the most conspicuous structure is a flat plate (*x*) which in its form and the serrations of its lateral margins suggests a barbaric spear head.

3. **Menacanthus robustus** (Kellogg).

Fig. 3.

Material examined. The single female upon which the species was originally based, from *Psaltriparus minimus*, Palo Alto, California, and a female and two males from *Penthestes rufescens neglectus*, Marin County, California. The figures are from the specimens from the second host as the type is not in the best of condition. The determination of these specimens is positive, however.

Female (Fig. 3 *A*). A robust and rather strongly chitinized form. *Head* noticeably short and broad, being slightly more than twice as wide as long, the greatest width close to the posterior border. Lateral margin very slightly excavated and with a distinct slit just in front of the eye (Fig. 3 *E*). Antennary fossa (Fig. 3 *F*) deep, backed up by an oval chitinized area, the ventral side partially floored by the prolongation of the temporal margin of the head, this much exceeded by the dorsal margin. *Antennae* (Fig. 3 *C*) four-segmented. Labial palpi slender. From just behind and slightly lateral of the base of the palpus (Fig. 3 *F*) arises a stout, backward pointing spine which is apparently an outgrowth from the internal skeleton at this point. Gular region with a large, but rather weakly chitinized plate which bears several long setae.

Prothorax rather large and broad, with moderately acute wings, the lateral margins strongly convergent but not merged with the posterior margin; sternum with a small plate which bears a few small setae. *Mesothorax* much reduced, the notum consisting merely of a faint transverse band; sternum with a small chitinized plate bearing several small setae; coxal cavities margined by a strongly chitinized band. *Metathorax* with the lateral margins strongly divergent, the posterior margin straight; sternum distinctly chitinized

and bearing several small setae. *Legs* of ordinary form, the anterior femora not expanded, the posterior femora with merely a few scattered setae on the ventral side.

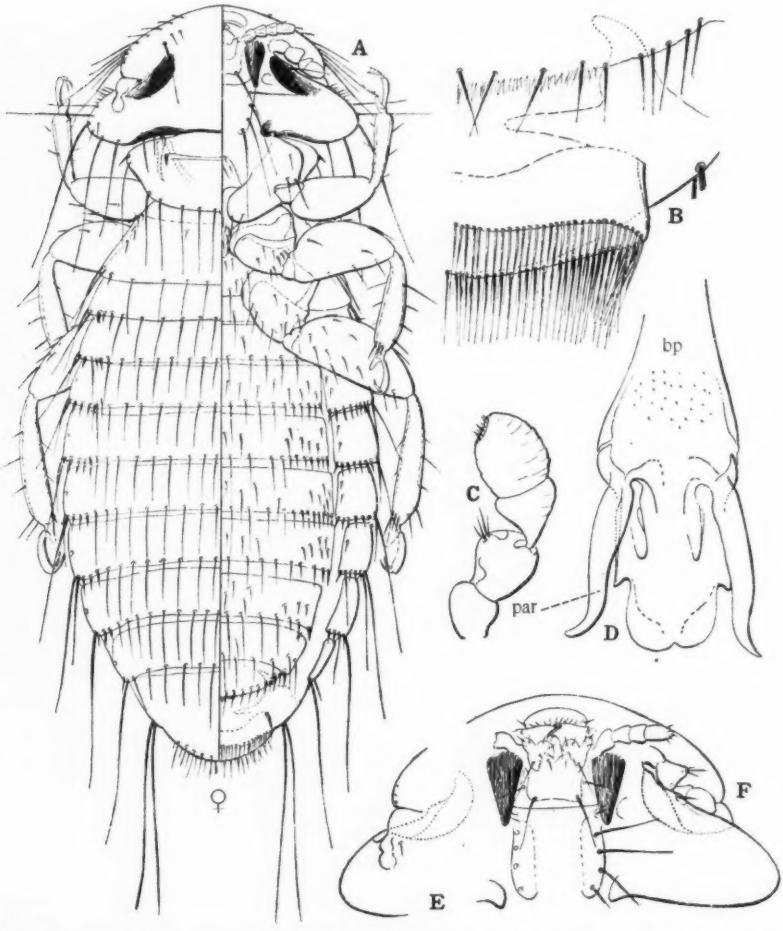

Fig. 3. *Menacanthus robustus* (Kellogg). *A*, female; *B*, portion of ventral aspect of genital region of female; *C*, antenna; *D*, genitalia of male; *E*, outline of dorsal aspect of lateral margin of head; *F*, portion of ventral aspect of head.

Abdomen quite broad, the plates well defined and strongly chitinized. Tergites continuous with the pleurites and extending to the ventral side of the body, bearing a single marginal row of small setae except in the pleural region where these give way to short, stout setae together with one or two that are long and slender. Sternites with a few small, irregularly disposed

setae which are somewhat clustered at the lateral margins but not sufficiently to form distinct brushes. Spiracles extremely small, present on the third to eighth segments. Apex of the abdomen rounded, the ventral side (Fig. 3 *B*) with a circlet of closely set, slender setae, without gonapods.

Male. Practically identical with the female in general characters. *Genitalia* (Fig. 3 *D*) with the basal plate (*bp*) long and slender, the apex expanded and articulating with a pair of outwardly curved pieces that I take to be the parameres (*par*). Between the parameres is a plate that is apparently a prolongation of the preputial sac.

4. **Pseudomenopon tridens** (Nitzsch).

Fig. 4.

Material examined. Females from *Fulica atra*, Ain, France, received through the kindness of Professor J. Pelosse of the Faculty of Sciences of Lyons, and a male and female from *Fulica americana*, Lawrence, Kansas, U.S.A. The latter specimens are a part of the co-type material of Kellogg's *Menopon tridens pacificum* but I can see no basis whatsoever for separating them from the European form in any degree. The figures of the female are from the European specimens and of the male from the American specimens.

Female (Fig. 4 *A*). A moderately robust form. *Head* triangular in general outline, very slightly wider than long, the greatest width across the posterior margin. Lateral margins (Fig. 4 *E*) not at all excavated, forming an unbroken parabola, with a distinct slit in front of the eye. This slit is backed up by a small but strongly chitinized area, from which a faint band extends to the posterior border of the head to meet a narrow occipital band. Pharyngeal sclerite and glands apparently lacking. Antennary fossa very deep, the dorsal and ventral borders almost coinciding. Antennae four-segmented, the second segment with a marked anterior expansion, the fourth short and broad.

Gular region (Fig. 4 *F*) with a remarkably modified plate. This appears to consist of an elongate central piece which is attached only at its anterior extremity and is flanked by a narrow and less heavily chitinized piece on each side. The whole structure is apparently merely the modified gular plate and it does not project past the posterior margin of the head.

Prothorax large and broad the lateral margins moderately convergent; sternum with a distinct plate but without setae. *Mesothorax* much reduced, the notum very faintly indicated; sternum with a distinct and large chitinized plate which bears a very few small setae; coxal cavities margined by a very distinct band. *Metathorax* with the lateral margins quite strongly divergent, the posterior margin straight; sternum with a very small plate. *Legs* of ordinary form, the anterior femora not expanded, the posterior femora with a somewhat indistinct brush of setae on the ventral side.

Abdomen with the plates well defined. Tergites continuous with the pleurites and extending somewhat to the ventral side of the body where they

terminate in a conspicuous, pointed process, margined with a series of small slender setae, these becoming longer and larger in the pleural region. Sternites with two partial rows of small setae and a slight clustering of setae at the posterior lateral angles hardly sufficient to be called a brush. Apex with a

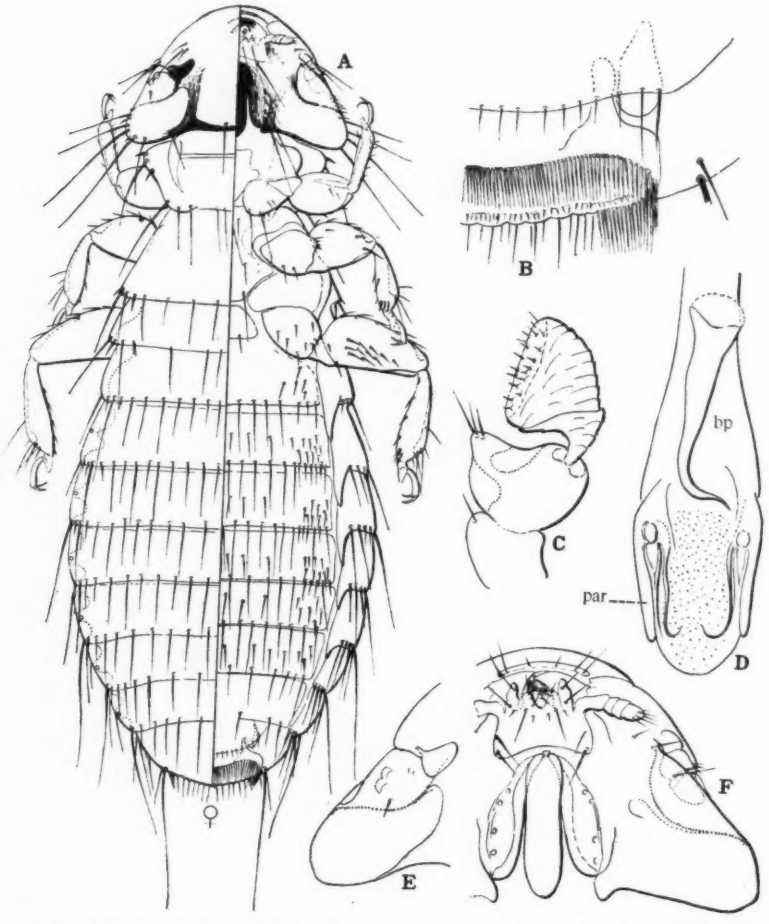

Fig. 4. *Pseudomenopon tridens* (Nitzsch). *A*, female; *B*, portion of ventral aspect of genital region of female; *C*, antenna; *D*, genitalia of male; *E*, outline of dorsal aspect of lateral margin of head; *F*, portion of ventral aspect of head.

rounded plate bearing a few small setae and on the ventral side a partial circlet of closely set, slender setae (Fig. 4 *B*); with small ventral, chitinized areas that perhaps are the vestiges of gonapods. Spiracles very small, present on the third to eighth segments.

Male. In its general characters practically the same as the female but much more slender, the body narrower than the head. *Genitalia* (Fig. 4 *D*) with a slender basal plate (*bp*) which is slightly expanded at the apex where it articulates with a pair of slender processes that are probably the parameres (*par*). Between these are vague structures that are apparently part of the preputial sac and overlying the apex of the basal plate is a conspicuous, trumpet-shaped structure that is part of the same organ.

5. **Somaphantus lusius** Paine.

Fig. 5.

Material examined. A single female from the type lot, received some years ago through the kindness of Mr J. H. Paine.

Female (Fig. 5 *A*). A very slender, weakly chitinized and hairy form. *Head* slightly longer than wide, the greatest width near the posterior border. Lateral margin (Fig. 5 *B*) very slightly excavated, without either a notch or a slit in front of the eye. Pharyngeal sclerite and glands strongly developed. Antennary fossa extremely shallow, open beneath. Antennae (Fig. 5 *D*) relatively very large, the terminal segment very elongate. It is difficult to decide whether there is a very minute third segment or whether this is merely the pedicel of the third. Labial palpi relatively very large, slender, much exceeding the margin of the head. Gular region (Fig. 5 *C*) not chitinized, but bearing four pairs of long setae. Across the gular region there extends a faint band that is apparently internal and that terminates on each side in a clear area.

Prothorax relatively rather large, about two-thirds as long as wide, without wings; sternum not chitinized. *Mesothorax* with the notum very much reduced, but quite definitely indicated by a transverse, chitinized band, and with the sternum noticeably enlarged, encroaching upon the metathorax so that the anterior and middle legs are widely separated; sternum with numerous slender setae. *Metathorax* scarcely distinguishable from an abdominal segment, with the sternum quite large and encroaching upon the first abdominal sternite and bearing numerous small setae. *Legs* of ordinary form, the anterior femora not enlarged, the posterior femora with a distinct brush of small setae on the ventral side.

Abdomen long and slender, unchitinized, all the segments with a closely set row of slender setae along the posterior margin and numerous scattered setae elsewhere, together with long setae at the lateral margins. Fourth sternite with a pair of distinct brushes of small setae. Apex of the abdomen with a rounded plate fringed with a few small setae; ventral side without vestiges of gonapods. Spiracles evidently extremely minute as I have been unable to detect them.

Male. According to Paine the male is larger than the female. His figure and description of the genitalia are of no aid.

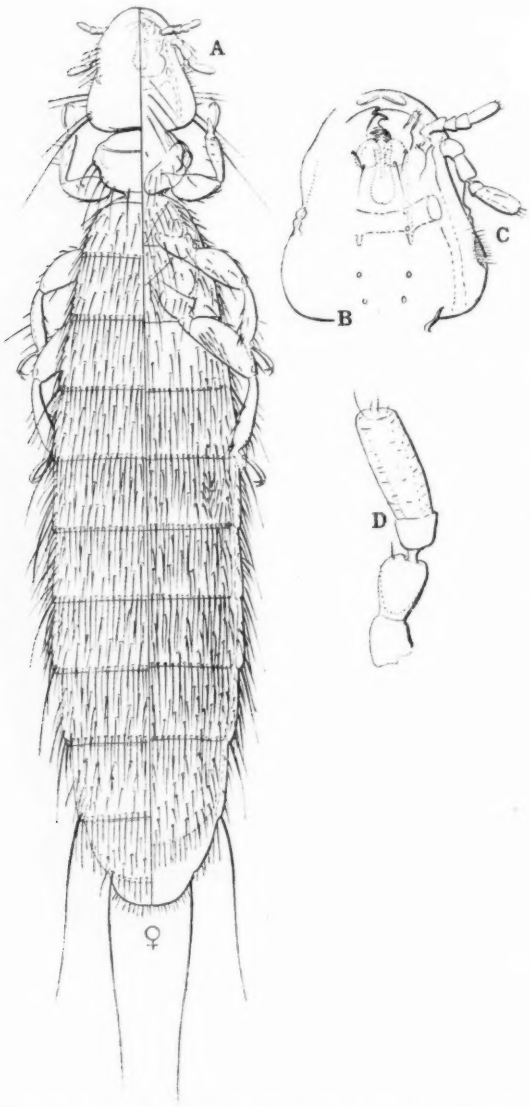

Fig. 5. *Somaphantus lusius* Paine. *A*, female; *B*, outline of dorsal aspect of lateral margin of head; *C*, portion of ventral aspect of the head; *D*, antenna.

(*MS. received for publication* 9. IX. 1923.—Ed.)

DISTRIBUTION OF SNAILS SERVING AS INTERMEDIATE HOSTS OF FLUKES IN SOUTH AFRICA.

By F. G. CAWSTON, M.D. (Cantab.).

VARIOUS ISIDORAE ARE RESPONSIBLE FOR THE SPREAD OF AMPHISTOMIASIS IN SOUTH AFRICA.

When, in 1917–18, I made a microscopic examination of freshwater snails at Potchefstroom, Transvaal, I found 10 per cent. of the examples of *Isidora schackoi* Jickeli infested with eye-spotted cercariae which Dr E. C. Faust recognised as amphistomes. Some shells which I collected from the same pools and considered to be immature examples of *Isidora schackoi* have been identified as *Sericima*. It is possible that the two species are identical. I found *Isidora forskali* at Cato Manor, outside Durban, infested with amphistomes, and confirmed this observation by isolating similar cercariae from the same freshwater snail on the Umgeni flats. I have obtained examples of *Isidora forskali* from Amanzimtoti, Isipingo, Clairwood, Umhl-a-tazana, Cato Manor, Inchanga station, Umgeni, Tongaat, Nonoti, Umzindusi, at Pietermarizburg, Lourenço Marques and Beira. These places constitute several new localities for the species and no Isidorae had previously been recorded from Beira. This mollusc is common in small shallow spruits and is often attached to small plants or water-lily leaves. It is seldom more than 10 mm. in length.

I have also obtained amphistomes in *Isidora tropica* at Mayville and at Shuttes' Draai on the Basutoland border of the Free State. At this latter place the majority of the maturer specimens which I dissected were amphistome-infested and the cercariae rapidly became encysted on the glass slide. Occasionally the shell of this snail attains 16 mm. in length, both in the Free State and in Natal. My collection contains specimens from Illovo, Umbogintwini, Isipingo, Umbilo, Mayville, Sydenham, Umgeni, Umhlangana, Umhlanga, Umhloti in Natal and from Schuttes' Draai and Clocalan in the Free State.

Some Isidorae which Mr Grobbelaar posted to me from Stellenbosch and in which he had found cercariae resembling *C. frondosa*, were suspected by Mr H. C. Burnup of being *Isidora verreauxi* Bttg.

The only other freshwater snail in the Union which I have found infested with amphistomes is *Isidora natalensis*, fine examples of which were collected from the water-lily leaves under the Amatikulu bridge. This species may be identical with *I. diaphana*. So far I have not secured any adult amphistomes in animals (*a*) fed on green food containing the cysts of these cercariae or (*b*) injected with cercariae.

OUR COMMONEST FRESHWATER SNAIL, *LIMNAEA NATALENSIS*, IS THE USUAL CARRIER OF FASCIOLAE OF SHEEP AND CATTLE IN SOUTH AFRICA.

Fasciola gigantica has been found in its larval stage in two distinct species of freshwater snail examined by me, namely *Limnaea natalensis* from Lake Chrissie in the Transvaal, and from Sydenham near Durban and *Physopsis africana* from Avoca along the north coast of Natal. The distribution of these two common snails, inhabitants of semi-stagnant water, is a very wide one; I have collected numerous examples from areas as wide apart as Port Elizabeth and Amatikulu along the east coast and have found both species at Rustenburg, Scheerport, Magaliesburg, Klerksdorp and Mulder's Drift in the Transvaal; whilst, even in July, I found *Limnaea natalensis* at Schuttes' Draai and at Clocalan along the course of the Caledon tributary of the Vaal River. Dr Annie Porter has shown that both *Limnaea natalensis* and *Isidora tropica* can harbour the cercaria of *Fasciola hepatica*.

SEVERAL DIFFERENT SPECIES OF FRESHWATER SNAIL IN SOUTH AFRICA MAY CONVEY BILHARZIA INFECTION; BUT *PHYSOPSIS AFRICANA* IS THE COMMON CARRIER.

Although I do not know that *Schistosomum bovis* has been recognised as infesting South African animals in nature, Prof. R. T. Leiper identified this trematode without hesitation amongst the adults found by me in experimental animals exposed to infection with cercariae from *Physopsis africana* at Sydenham. Moreover, ova resembling those of *Schistosomum bovis* were present in three of my patients who lived near Durban. The presence in the freshwater snails of Natal of several schistosomes, closely allied to the two human parasites of the African continent but not identical with them, suggests that the parasites of animals are represented among them. I have found schistosomes occasionally present in *Physopsis africana*, *Isidora tropica*, *I. forskali*, *I. globosa*, *Limnaea natalensis*, *Planorbis pfeifferi* and *Segmentina planodiscus*.

About thirty distinct species of trematodes have been recorded from freshwater snails collected by me in various parts of the Union and Portuguese East Africa. These include: A non-mammalian schistosome from Lourenço Marques. Two eye-spotted schistosomes, the one from *Isidora* (*Physopsis*) *globosa* at Lourenço Marques and from a small shell believed to be *Physopsis africana* at Durban, the other from *Segmentina planodiscus* at the new Durban Country Club. Monostomes whose life-history is at present uncertain. Four styleted cercariae, one of which occurring in the Durban water-cress, is suspected of being *Paragonimus westermani*, the lung-fluke of the Far East. Six echinostomes.

(*MS. received for publication* 22. IX. 1923.—Ed.)

ON THE LIFE-CYCLE OF *HYMENOLEPIS FRATERNA* (*H. NANA* VAR. *FRATERNA* STILES) OF THE WHITE MOUSE.

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In recent publications Clayton Lane and G. C. Low (1923) call in question what may be termed the one-host account of the life-cycle of *Hymenolepis nana* var. *fraterna* Stiles (*Hymenolepis fraterna* of Joyeux), an account principally based on the work of Grassi (1887, 1892). The expressed ground for this scepticism is the inadequacy of the experimental work on which the one-host account is based, taken in conjunction with the *à priori* improbability that any tapeworm in a mammal should differ from all the other known tapeworms of mammals in not having an intermediate host in its life-cycle, and it must be admitted that even in Grassi's description of his experiments there is a great lack of essential details, and in Joyeux's confirmation (1920) of Grassi's results details are almost wholly absent. In view of the theoretical importance of the subject, the criticisms of Clayton Lane and Low are certainly welcome, and it is desirable to decide once for all whether *Hymenolepis fraterna* can or cannot complete its life-cycle in the mouse (or rat) alone, *i.e.* can or cannot infest the same individual animal both in the cysticercoid and in the sexual stage of its development. The present communication is the outcome of a renewed attempt to settle the problem, and I may say at once that my experiments prove conclusively that Grassi was correct in his view.

PROCEDURE OF THE EXPERIMENTS.

From the large stock of mice kept in the Wellcome Bureau Animal House and from outside sources I selected between May 22nd and June 6th, 1923, 63 individuals which, after two examinations of the faeces conducted on two successive days, were found to be free from *Hymenolepis* eggs, and on June 14th I selected another six mice, similarly found free from eggs after two examinations, making 69 mice in all. To obtain these I examined altogether 114 mice, eight only of which I rejected on account of *Hymenolepis* infection, 24 on account of acute Coccidiosis, one on account of acute infection with *Trichomonas*, and four I killed for the identification of a common parasitic Nematode (*Oxyuris tetraptera*), and eight died from unknown causes.

On June 7th, 12th and 15th I examined the faeces of all the 63 selected mice (*i.e.* excepting the six selected on June 14th, of which I shall give a separate account below) for the third time and found nine to be infected with *Hymenolepis*, and these, with further rejections due to acute Coccidiosis and deaths, reduced the number to 54.

On June 19th I made the fourth faecal examination of the 54 mice and found two more *Hymenolepis*-infected, and these, with deaths, reduced the number to 47. Of these 47 the

"youngest" were 15 days old (*i.e.* 15 days had elapsed since the first faecal examination) and the "oldest" 28 days.

On June 26th and 27th I made the fifth faecal examination and found no instances of *Hymenolepis* infection but, owing to three more deaths, the number of mice (not including the six selected on June 14th) was reduced to 44.

On July 10th I made a sixth faecal examination of these mice, the number of which, owing to deaths, was now reduced to 40 and found one case of very slight infection with *Hymenolepis*.

On July 12th I made the seventh examination, on July 13th the eighth, on July 16th the ninth and on July 17th the tenth examination, and found no further cases of *Hymenolepis* infection but with further deaths the number of mice was now reduced to 34. Of these 34 the "youngest" mice were 42 days "old" and the "oldest" 55 days "old," and since, according to Grassi and Rovelli, the average length of time taken by the worm to arrive at maturity and therefore to shed eggs is about 30 days, and according to Joyeux only 14 days, I felt fairly confident that these 34 mice were absolutely free from *Hymenolepis* infection. I felt the more assured because the large majority of them belonged to a stock which was procured from outside the Wellcome Bureau and which from the first had proved *Hymenolepis*-free (and also free from other parasites), all the cases of *Hymenolepis* infection which I had discovered from the third to the sixth examinations having occurred in animals which I had selected from the original stock in the Bureau Animal House, a certain percentage of which I knew to be infected.

Of the six additional mice selected on June 14th, one only showed a very slight *Hymenolepis* infection on the fourth examination (on July 11th when these mice were 27 days "old")—an infection which might have been discovered sooner but for an interval of 13 days during which I was unable to examine them—and during the four subsequent examinations (the last on July 17th when the mice were 33 days "old") no further cases of infection were found.

On July 20th, owing to four further deaths, I possessed altogether only 35 *Hymenolepis*-free mice (the "youngest" at the last faecal examination being, as just stated, 33 days "old" and the "oldest" 55 days), but these I considered were sufficient for my purpose and on that date I performed the egg-feeding experiment related below. The probable cause of the relatively high death-rate which will have been noticed in the preceding statement I shall refer to later in this Section.

I will now state details relating to the feeding and general care of the mice, since these are all-important in experiments which have as a principal object the prevention of contamination of the food with *Hymenolepis* eggs.

Mice proved to be free from *Hymenolepis* eggs after two examinations were removed to a separate room four floors away from other mice kept in the Bureau, and habited in new cages on high wall shelves to prevent possible visits from wild mice. The cages were so placed that the wired openings were vertical, thus rendering it difficult for the faeces of wild mice, if present, to drop into the cages, and the wired openings were, for the same purpose, covered with fine wire gauze—a device which also excluded flies. The cages were cleaned, under my personal supervision, about once a week by immersion in 3 per cent. lysol and then 90 per cent. alcohol and, especially in cases in which the cages had harboured *Hymenolepis*-infected mice, the interiors of the cages were well flamed (with a large Bunsen burner) in addition.

The mice were fed daily during the first five or six weeks of the experiments on fresh or one-day-old bread placed in a china pot of clean water, with cheese twice a week. The pots were daily cleaned by me (and boiled after a case of *Hymenolepis* infection) and fresh bread given, but I now feel certain that this mode of feeding[1] was the principal cause of the

[1] Grassi fed his rats on bread and water only.

heavy mortality which occurred. The majority of the mice which died showed evident signs of vitamine-deficiency, the external signs being emaciation and anaemia (specially noticeable in the tail), lack of growth and later a paralysis of the limbs and a humping of the back, and the internal signs (as kindly ascertained for me by Dr A. C. Stevenson) being internal haemorrhage in the region of the hind brain and a marked swelling of the axis-cylinders seen in sections of the spinal cord, denoting peripheral neuritis. To remedy this state of things I decided, though only as late as July 17th, to add to the diet carefully-washed lettuce (Osborne and Mendel, 1922) and to provide new bread not placed in the water, and subsequent to this change of diet the mortality markedly decreased (in fact ceased altogether, after allowing for those cases in which vitamine-deficiency had gone too far to be remedied) and the general health and rate of growth of the mice decidedly improved and continued to be good. The avidity with which mice feed on green stuff (even when grain is supplied) is proof that they need it. Fortunately the vitamine-deficiency was remedied in time to prevent the main object of the experiments being interfered with, and the only result of this defect was to prevent me conducting the work on the large scale that I had originally intended. Separate brushes were of course used for cleaning the cages and pots of *Hymenolepis*-infected and *Hymenolepis*-free mice, and all instruments were carefully sterilized after use. The bottoms of the cages were covered with sterilized sawdust and the "bed-chambers" with clean cotton-wool, both frequently renewed. Each mouse had its own cage and its own pot of water throughout the experiment. The entire work of the feeding and cleaning was done by me personally for fear that laboratory attendants, coming from contact with animals in the Animal House, might introduce infected material. *Hymenolepis*-infected mice which I collected as a source of eggs for the final phase of the experiments were kept in a separate room four floors below that in which I kept the *Hymenolepis*-free mice, and the former were always cleaned and fed *after* the latter had been attended to.

After the second faecal examination all of the mice (excepting the six selected on June 14th) were freed as far as possible from ecto-parasites by anaesthetizing them with ether on two occasions (in some cases three) and by thoroughly brushing the fur on all parts of the body with a stiff tooth-brush when anaesthetized. In this way I removed from some of the mice as many as two or three hundred or more lice (*Haemotopinus spinulosus*) from each individual but from the majority 20 to 50 and in some cases less than a dozen or none. Out of all the 63 mice examined in this way I obtained only two fleas (*Ctenopsylla musculi*) —a singularly flea-free stock. Thus the flea, considered as an intermediate host, certainly cannot have acted as such among the mice I experimented with.

In the examinations of the faeces of the mice I adopted what may be termed the "soup" method: in other words, the faecal pellets (usually four or five in number) being so small, they were simply broken and stirred up with a small quantity of water until a uniform mixture was obtained and two or three samples of this examined on a slide under a cover-slip. Centrifuging was unnecessary. The grinding-up of the faeces was effected with a small agate pestle (easily cleaned with a brush under a tap after each examination) in a watch-glass. It is advisable to avoid the inclusion of small granules of bread with the faeces since the refringent starch granules interfere somewhat with the detection of the refringent hexacanth embryos of the eggs. Mice to be examined were usually temporarily placed in large cylindrical glass jars for the collection of faeces, the jars afterwards being thoroughly cleaned. Fresh faeces are of course preferable to dried faeces. When I mention that, out of the hundreds of faecal examinations made by me, only in one instance did I detect *Hymenolepis* eggs in a second examination when, in the first examination made on the previous day, the eggs had been recorded as absent, and that, only in one instance did I record eggs as absent and yet found a single mature *Hymenolepis* in the mouse examined immediately afterwards, the accuracy of the vast majority of the examinations is sufficiently assured.

THE FEEDING OF THE MICE WITH RIPE *HYMENOLEPIS FRATERNA* EGGS AND THE RESULTS OBTAINED.

As already stated I possessed on July 20th 35 mice which, for periods varying between 33 days and 55 days, had, by 10 faecal examinations spread over these periods, been proved to be free from *Hymenolepis* infection. The majority of these appeared to be in good health. Bearing in mind Joyeux's contention that young mice only are readily infected[1], I selected from these 35 mice 20 of the smallest (the "youngest" of which was 42 days "old" on July 17th) for feeding with *Hymenolepis* eggs, reserving the other 15 larger mice (including the five first selected on June 14th and 33 days "old" on July 17th) as controls.

I had previously kept in the separate room mice which I had found to be naturally infected but of these, owing to a number having been killed for examination, to others being infected but lightly and to some having apparently lost their tapeworms (*vide infra*), only five remained. On July 18th and 19th therefore I examined another 40 mice from the Animal House and found another 11 well-infected mice, making 16 well-infected mice altogether. On the morning of July 20th I placed these 16 infected mice in 16 jars and collected faecal pellets from those (about eight) which contained a large number of pellets. About six of these collections of pellets (from six individual mice) being found to be richly infected with eggs, I, with the aid of Mr Muggleton, opened the mouth of each of the 20 selected mice and inserted one pellet which we made certain was swallowed. In the cage of each of these 20 mice I also placed a small solid flat-bottomed shallow glass receptacle containing as their sole food for the next 24 hours a cube of bread about the size of a small lump of sugar, soaked with milk and freely sprinkled with a quantity of richly egg-infected centrifuged faecal "soup" made from the remaining and fresh pellets of the infected mice already used. By next morning each of the 20 mice had eaten the whole of the cube of bread. There was thus no doubt but that each mouse had swallowed at least 20 and more probably 50 or more living *Hymenolepis* eggs. The 15 control mice were, as always, fed in exactly the same way as the egg-fed mice, save of course that no *Hymenolepis* eggs were given, and were kept under identical conditions and in the same room, though on opposite sides.

On July 21st one of the 15 control mice, which had appeared sickly on the previous day, was found dead, thus reducing the number of controls to 14.

On this day also I put the 20 egg-fed mice together in pairs in 10 cages instead of keeping each mouse in a separate cage—a proceeding I had cause to regret later. I also placed the 14 control mice in pairs.

I shall now record the results of the examination of each mouse individually.

On July 23rd all the mice appeared to be in good health and I killed one labelled *A* 4.

[1] According to Grassi and Rovelli rats younger than one month are not easily infected.

Three days after infection.

Mouse A 4. Killed on July 23rd, three days having elapsed since ingestion of *Hymenolepis* eggs. This mouse was 50 days "old" at the tenth faecal examination and weighed at death only 11·6 gm. (vitamine deficiency).

In this mouse I removed the last 15 cm. of the small intestine, slit it open and flattened it out between glass slides under pressure and fixed in 90 per cent. alcohol for about four hours. I then removed the slides and stained the intestine in dilute borax carmine for about 12 hours and mounted it in balsam. In previous trials of this method, when I had kept the intestine flattened in alcohol overnight, the intestine walls had remained well flattened and all the villi showed well, but on this particular occasion the method was not a success owing to imperfect fixation.

My friend Dr Wenyon however detected in these preparations what was almost certainly one cysticercoid, and in the sections into which the preparations were subsequently cut, what was probably another cysticercoid was seen, but the bad preservation of the tissues prevents me from stating for certain that cysticercoids were present, though they probably were.

Five days after infection.

Mouse D 2. Killed on July 25th, five days since the egg-feeding. This male mouse was 42 days "old" at the tenth faecal examination and weighed at death only 11·452 gm.

In this mouse and in all the other mice I adopted a different method for detecting Cestode infection in the intestine. This method was to slit open short lengths of the hind small intestine, to scrape their surface with a scalpel, to tease up the scrapings in water on a slide and to examine them as for faeces. The lengths of intestine and the faecal contents should also be examined independently.

In the hindermost 4 cm. of the intestine of *D* 2 I found one small plerocercoid larva: in the next 4 cm. of the intestine I found five more small plerocercoids, measuring between 0·249 mm. and 0·348 mm. in length, and in the next 4 cm. I found another 0·249 mm. long, making six in all. I fixed these plerocercoid larvae on coverslips in Schaudinn's Fluid and stained with dilute Mayer's Acid Haemalum.

Seven days after infection.

Mouse D 9. Killed on July 27th, seven days since the egg-feeding. This mouse (♀) was 42 days "old" at the tenth faecal examination and weighed at death only 7·565 gm. This mouse on the previous day had evinced paralysis in the hind legs and would doubtless have died in a day or so (vitamine deficiency).

Last 3 cm. of intestine.	Nil.
Next „ „ „	Nine small plerocercoids found, measuring between 0·182 mm. and 0·464 mm. in length.
„ „ „ „	Ten plerocercoids found, measuring 0·265 mm. to 0·398 mm.
„ „ „ „	Nil.
„ „ „ „	Four plerocercoids found, measuring 0·282 mm. to 0·298 mm.
„ „ „ „	Nil.

Thus in all 23 plerocercoid larvae were found.

Ten days after infection.

Mouse C 12. Killed on July 30th, ten days since egg-feeding. This mouse (♀) was 46 days "old" at the tenth faecal examination and was the smallest I possessed. Owing to vitamine deficiency it had hardly grown at all since I first selected it and it was thin

and inactive, though no paralysis had yet appeared. This was the last of the sickly mice, all the others being in perfect health. It weighed at death only 6·02 gm.

Last 3 cm. of intestine.	Nil.
Next „ „ „	One plerocercoid 0·464 mm. long.
„ „ „ „	One plerocercoid 0·448 mm. long.
„ „ „ „	Three plerocercoids measuring 0·348 mm. to 0·481 mm.
„ „ „ „	Nil.

Fourteen days after infection.

Mouse D 18. Killed August 3rd, 14 days since egg-feeding. This mouse was 42 days "old" at the tenth faecal examination and weighed 18·38 gm. at death, this mouse, like all the other healthy mice, having put on weight considerably since it was fed on lettuce. It was examined for fleas, but, needless to say, none was found.

Last 3 cm. of intestine.	One tapeworm nearly 7 mm. long.
Next „ „ „	About 16 tapeworms, measuring from about 6 mm. to 10 mm.
„ „ „ „	About 25 tapeworms 2·2 mm. to 5 or 6 mm. in length.
„ „ „ „	Nil.

Some of these tapeworms contained obviously-ripe eggs, but on examination of the faeces in the rectum no eggs were found.

Two features in this Cestode infection of *D* 18 call for comment. The first is the obvious enormous gap in the sizes of the tapeworms found in *C* 12 and *D* 18 respectively. Though the worms of the latter were only four days older in their development than those of the former, yet, comparing the largest plerocercoid of *C* 12 with the smallest tapeworm of *D* 18, the latter had increased in bulk nearly five times. At the time I attributed this gap to the circumstance that *C* 12 (and *D* 9) was in bad health, a condition which may have had a retarding effect on the growth of the worms, and I therefore decided, in order to test this idea, to infect another five of the remaining uninfected 14 control mice, thus only leaving nine mice as complete controls. This was done (though ineffectually, as it proved) on August 7th and the result will be stated below. I may here mention that, for reasons to be supplied later, I do not think that the growth of the tapeworms had been affected by the health of the mouse, but that the gap, as regards size, between the worms of *C* 12 and *D* 18 was purely fortuitous.

The other feature in the Cestodes of *D* 18 is the marked difference in size between the smallest and the largest of the worms contained in this mouse[1]—a difference about equally as marked as that which I have just commented upon in comparing the worms of *C* 12 and *D* 18, and it is absolutely certain that all the worms of *D* 18 belong to one generation, since the mouse *D* 3 (*vide infra*), with which *D* 18 was paired, only contained very immature worms when it was killed on August 8th, *i.e.* 19 days after infection.

THE FIRST APPEARANCE OF EGGS IN FAECES.

On August 4th, 15 days after the mice had been fed with *Hymenolepis* eggs, I examined the faeces of four of the remaining 15 egg-fed mice—*A* 1, *A* 2, *AB* and *C* 2—to ascertain if eggs were being shed, and I found that

[1] Grassi obtained similar results.

in *A* 2 and *C* 2 this was the case. Hence *Hymenolepis fraterna* can develop so as to shed eggs certainly in 15 days, and possibly in 14 days, as stated by Joyeux[1].

On August 5th (16 days after egg-feeding) I examined the faeces of all the mice other than *A* 2 and *C* 2—13 mice—and I found *Hymenolepis* eggs in seven of them, *i.e.* in *C* 7, *C* 8, *C* 9, *D* 6, *D* 10, *D* 12 and *D* 15 (it is important to note which of these mice showed eggs in the faeces). Thus, on the sixteenth day after egg-feeding, nine out of 15 mice showed eggs in the faeces.

On August 8th (19 days after egg-feeding) I examined the stools of the six mice which had not shown eggs in the faeces on August 5th—in *A* 1, *AB*, *C* 1, *D* 3, *D* 8 and *D* 14—and still found no eggs. I decided to kill and examine these six mice on this day.

Mice showing no eggs in faeces on the nineteenth day after infection.

Mouse A 1. Killed August 8th, 19 days since egg-feeding. This mouse (♂) was 50 days "old" at the tenth faecal examination and weighed 25·3 gm. at death.

I could find no worms in the intestine: the only entirely negative result I obtained out of all the 20 mice infected.

Mouse AB. Killed August 8th, 19 days since egg-feeding. This mouse (♂) was 54 days "old" at the tenth faecal examination and weighed 24·75 gm. at death.

In the last 12 cm. of the intestine I found only one portion (consisting of mature proglottids which however I did not examine in detail) of a large tapeworm. I am of opinion that probably only one worm was developed in this mouse, that it was about to be eliminated in the faeces and that, with such a slight infection (of one worm), I had either previously omitted to observe the eggs in the faeces, or the eggs had not yet been discharged (as I have said, I unfortunately omitted to settle this point). An alternative explanation is that the worm had shed all its eggs previous to August 4th—a not impossible supposition as facts shortly to be stated will show (*vide D* 12 *infra*).

Mouse D 3. Killed August 8th, 19 days since egg-feeding. This mouse (♂) was 42 days "old" at the tenth faecal examination and weighed 23·97 mm. at death.

In the last 13 cm. of the intestine I found four immature tapeworms, measuring only 0·830 mm., 0·833 mm., 1·676 mm. and 1·826 mm. respectively, though 19 days "old." This and similar observations that follow are of interest in connection with the developmental gap (see Mice *C* 12 and *D* 18) previously referred to.

Mouse D 14. Killed August 8th, 19 days since egg-feeding. This mouse (♀) was 42 days "old" at the tenth faecal examination and weighed 20·65 gm. at death.

Last 3 cm. of intestine. Nil.
Next 6 cm. „ „ I found three plerocercoids, two 0·415 mm. and one 0·498 mm. long.

These results with *D* 14 are thus even more remarkable than those obtained with *D* 3 and I believe can only be explained on the supposition of delayed development[2]. Since *D* 14 was paired with *D* 6, an alternative explanation is that *D* 14 had recently swallowed some of the eggs present in the faeces of *D* 6 and this possibility cannot be denied[3]. On the other hand, it is evident

[1] Grassi gives 30 days for the first appearance of the eggs!

[2] Grassi obtained similar results.

[3] According to Grassi and Joyeux, rats and mice harbouring *Hymenolepis fraterna* are refractory to further infection.

that the tapeworms found in *D* 3 show decided delay in development[1] and therefore it is possible that the tapeworms of *D* 14 were also, but more distinctly, delayed in their development.

Mouse D 8. Killed August 8th, 19 days since egg-feeding. This mouse (♂) was 42 days "old" at the tenth faecal examination and weighed 21·35 gm. at death.

Last 4 cm. of intestine.	Two plerocercoids 0·498 mm. and 1·328 mm. (scolex detached) long respectively.
	Two portions of a mature worm (one portion containing eggs).
	One entire worm about 5 mm. long.
Next 9 cm. „ „	Nil.

I was particularly careful here not to confuse young plerocercoid larvae with detached scolices and necks of older worms.

Since *D* 8 was paired with *D* 10, the faeces of which contained eggs on August 5th and possibly before this date, it is possible that the plerocercoids are due to infection subsequent to the egg-feeding on July 20th. Personally I am inclined to believe that this is also a case of delayed development. The mice were always supplied with abundance of food and the cages were kept well cleaned, and mice under these conditions are not likely to have ingested the faeces of other mice during five days.

Mouse C 1. Killed August 8th, 19 days since egg-feeding. This mouse (♂) was 49 days "old" at the tenth faecal examination and weighed 21·6 gm. at death.

Last 2 cm. of intestine.	One piece (just over 1 mm. long) of a young tapeworm in which segments were just becoming distinguishable.
Next 3 cm. „ „	One plerocercoid 0·664 mm. long.
„ 6 cm. „ „	Nil.

Thus of the six mice, the faeces of which showed no eggs on August 8th, one (*A* 1) had apparently remained uninfected, one (*AB*) had apparently been infected with only one worm, the eggs of which I had either failed to see or they had not yet been discharged in the faeces, one (*D* 3) contained four immature worms under 2 mm. in length, one (*D* 14) contained three plerocercoids all under 0·5 mm. in length, one (*D* 8) contained two plerocercoids and two mature or nearly mature worms, and one (*C* 1) contained two plerocercoids or small worms less than 2 mm. in length.

Since, as was shown in the case of *C* 12, in which subsequent infections were impossible, worms can have their development so delayed that in ten days they only reach a maximum length of 0·481 mm., and since, as was shown in *D* 18, worms in the same mouse can develop so unequally that some may attain a size nearly five times greater than the others[2], I believe that improved experiments with the mice kept separate, will prove that in all the cases just described, the inequalities of size of worms in the same mouse and of worms of the same age in different mice are solely due to different rates of development and not to subsequent chance infections. It is conceivable and indeed probable that in *limited* infections it is of advantage to

[1] Since, *D* 3 having been paired with *D* 18 (*vide supra*) which, though containing large numbers of tapeworms, some 10 mm. in length, yet had showed no eggs in the faeces on the fourteenth day after infection, it is impossible to suppose that *D* 3 was infected subsequent to July 20th.

[2] See also *D* 10 and *D* 15 below in which the worms are still more unequal in size.

the parasite that different worms should come to maturity at different ages, so that the stream of eggs may be more continuous, rather than that all the worms should arrive at maturity at the same time and all the egg-shedding be completed in a relatively brief period. That the period of egg-shedding may be very brief in many individual worms is certain, not only from the facts yet to be described but from the relatively few eggs contained in each proglottis. Moreover, eggs shed respectively from young and old mature worms possibly differ in their rate of development, and the health and size of the mouse and the number of eggs ingested may also be factors. Apart from these considerations however, it is also possible, that in the six cases just described, the mice may have eaten some of the eggs spread on the bread much later (even as much as 20 hours later) than those contained in the faecal pellet swallowed, and probable that eggs and cysticercoids may be delayed in their passage down to the hind extremity of the small intestine, and these factors would also in part account for the inequalities of size of the worms contained in the same mouse.

I now proceed to describe the infections of the remaining egg-fed mice which showed eggs in their faeces on August 5th.

Mice which showed eggs in faeces on the sixteenth day after infection.

Mouse D 6. Killed August 8th, 19 days since egg-feeding. This mouse (♂) was 42 days "old" at the tenth faecal examination and weighed 20·03 gm. at death.

Last 3 cm. of intestine.	One plerocercoid about 0·700 mm. long.
Next 7 cm. ,, ,,	Two plerocercoids 0·697 mm. and 0·913 mm. long respectively.
,, 5 cm. ,, ,,	Nil.

Yet this mouse showed eggs in the faeces 16 days after egg-feeding! It is almost certain that the mature worm or worms which shed the eggs had been evacuated (*vide D* 12 *infra*). Since this mouse *D* 6 was paired with *D* 14 (*vide supra*) subsequent infection was impossible.

Mouse D 10. Killed August 8th, 19 days since egg-feeding. This mouse (♀) was 42 days "old" at the tenth faecal examination and weighed 22·89 gm. at death.

Last 3 cm. of intestine.	Three portions (including the scolex and neck) of a worm which was probably mature.
Next 9 cm. ,, ,,	Two young worms 1·294 mm. and 0·830 mm. long respectively.
	Another ditto with scolex detached.
	Long narrow portion of an older worm 3·320 mm. long.
,, 5 cm. ,, ,,	Nil.
Caecum and colon.	Nil.

Since *D* 10 had been paired with *D* 8, subsequent infection with eggs from *D* 8 is excluded.

Mouse C 7. Killed August 9th, 20 days since egg-feeding. This mouse (♀) was 49 days "old" at the tenth faecal examination and weighed 17·18 gm. at death.

Last 3 cm. of intestine.	Seven plerocercoids or young worms measuring from 0·597 mm. to 1·593 mm. in length.
Next 4·5 cm. ,,	Scolex and neck of a probably mature worm.
,, ,, ,, ,,	Nil.

C 7 was paired with *D* 15 (*vide infra*), so infection subsequent to the egg-feeding was certainly possible in this case.

Mouse D 15. Killed August 9th, 20 days since egg-feeding. This mouse (♂) was 42 days "old" at the tenth faecal examination and weighed 16·6 gm. at death.

Last 3 cm. of intestine. An enormous infection of about 50 worms, ranging from 1·328 mm. to over 10 mm. in length.
Next 3 cm. „ „ About 20 worms varying in length from 2·490 mm. to about 6 mm.
„ „ „ „ Nil.
The variation in size of the worms is noteworthy.

TWICE-INFECTED MICE.

I have now described the results of the examinations of 15 of the 20 mice which were artificially infected on July 20th. Since these results were in some cases possibly due to natural infection subsequent to the artificial infection owing to the mice having been paired, I decided on August 7th to subject the five remaining egg-fed mice (which had shown eggs in their faeces on August 5th) to a second artificial infection in order to ascertain if two distinct generations of worms could be detected for certain in these mice[1]. Unfortunately the faecal matter which I employed for the second artificial infection was not richly egg-infected and, as will be seen more clearly in the accounts of the five control mice and the five young rats which I infected with the same material on the same day, the results were not satisfactory. To be certain of causing infection mice must ingest a considerable number of eggs.

Mouse C 2. Killed August 13th, 24 days after the first egg-feeding and six days after the second egg-feeding. This mouse (♀) was 49 days "old" at the tenth faecal examination and weighed 22·4 gm. at death.
Last 3 cm. of intestine. One young worm just under 7 mm. long.
Next „ „ „ One worm about 5 mm. or 6 mm. long (eggs visible in hind proglottids).
„ „ „ „ Nil.
Caecum and colon. Nil.
In this case therefore two generations of worms were certainly not present.

Mouse C 8. Killed August 13th. Mouse (♀) weighed 26·15 gm. at death. Other particulars as in *C* 2.
Last 3 cm. of intestine. Seven pieces of young immature worms.
Next 4 cm. „ „ Nil.
Caecum and colon. Nil.
The egg-laying worms had evidently been evacuated from the mouse (*vide D* 12 *infra*). A second generation of worms (six days old) was evidently not present.

Mouse C 9. Killed August 13th. Mouse (♂) weighed 20·02 gm. at death. Other particulars as in *C* 2.
Last 3 cm. of intestine. Eleven plerocercoids measuring 0·713 mm. to 0·996 mm. in length.
Next 4 cm. „ „ Nil.
The egg-laying worms had evidently been evacuated from the mouse (*vide D* 12 *infra*). Since these plerocercoids are larger than those found (*vide supra*) in *D* 2 (five days after infection), *D* 9 (seven days) or *C* 12 (ten days) and not much smaller than those found in *D* 3 (*vide supra*), it is difficult to say whether or not they belong to a second generation.

Mouse D 12. Killed August 13th. Mouse (♀) weighed 20·52 gm. at death. Other particulars as in *C* 2, save that the mouse was 42 days "old" at the tenth faecal examination.
Last 3 cm. of intestine. Four plerocercoids measuring 0·830 mm. to 1·079 mm. in length.

[1] According to both Grassi and Joyeux, already-infected rats and mice are refractory to further infection.

Next 4 cm. of intestine. Two plerocercoids 0·448 mm. and 0·996 mm. long, and *a portion of the hind region of a degenerate mature tapeworm, with proglottids of maximum size but empty of eggs and apparently full of fat globules.*

„ 3 cm. „ „ Nil.

It is evident that if the degenerate portion of the matured worm had not been found, the Cestode infection of this mouse would have resembled those of *C* 9, *C* 8, *D* 6, *AB* and other mice. I disintegrated the proglottids of this piece of matured worm and, as stated, eggs were entirely absent, having all been expressed, and the tissues were degenerating. In mice subsequently examined I found several other instances of these eggless degenerate matured worms, and they afford, in conjunction with the fact that mice which, having shown eggs in their faeces, on being opened, are found to contain no mature worms, convincing proof of Joyeux's statement that mice do evacuate their worms, sometimes after very brief periods of maturity of the worms.

Mouse A 2. Killed August 13th. Mouse (♂) weighed 26·15 gm. at death. Other particulars as in *C* 2, save that the mouse was 50 days "old" at the tenth faecal examination. A large *Cysticercus fasciolaris* was present in the liver.

Last 3 cm. of intestine. Four plerocercoids 0·664 mm. to 1·328 mm. long, and about 14 mature or nearly mature worms 5 mm. to 8 mm. long.

Next „ „ „ About one dozen worms 5 mm. to 10 mm. long. One young worm 2·988 mm. long. Five plerocercoids 0·780 mm. to 1·411 mm. in length.

In this mouse two more or less distinct generations of worms may have been present.

THE CONTROL MICE.

As previously stated, I possessed 14 control mice on July 20th, the "youngest" of which were 33 days "old" at the faecal examination made on July 17th. I examined the faeces of these mice again on July 26th and August 2nd (when the "youngest" were 46 days "old"), no eggs being found. On August 7th I fed five of these 14 controls (after having again examined their faeces and found no eggs) on a weak concentration of *Hymenolepis* eggs, as related in the next Section, but since only one out of the five became infected (examined on August 20th), the remaining four (the "youngest" of which was then 64 days "old") can still be reckoned as controls for the first infection of the 20 egg-fed mice.

The remaining nine controls were killed on August 9th and 10th (when the two "youngest"—*E* 2 and *E* 5—were 53 days "old" and the next "youngest" 69 days "old") and the last 9 cm. of their intestines most carefully examined, and no trace of infection was found. These results were kindly checked for me by Dr C. M. Wenyon.

It is thus certain that all the *Hymenolepis* infections of the 19 mice out of the original egg-fed 20 were due to the original egg-feeding, excepting perhaps some natural subsequent infections which may have occurred when the egg-fed mice were paired and excepting the second artificial infection of *C* 2, *C* 8, *C* 9, *D* 12 and *A* 2.

Direct infection, *i.e.* infection direct from the egg without an intermediate host, is thus proved for *Hymenolepis fraterna*.

THE ARTIFICIAL INFECTION OF FIVE OF THE CONTROL MICE.

In view of the remarkable differences in rate of development of the worms displayed in the results I had obtained when examining the original 20 egg-fed mice and the possibility that some of the very young worms found in some of the mice might have been due to the pairing of these mice I decided on August 7th to infect five of my 14 control mice to see if I obtained similar results when the mice were kept separate. With the confidence born of my previous success in infecting mice I neglected to obtain beforehand a number of mice with richly-infected faeces and relied upon the faeces of three or four mice which were only very moderately infected. With this material I infected on August 7th, by methods identical with those I originally employed, the five already-egg-fed mice above described (the twice-infected mice), the five controls now to be described, and five young rats (see next Section). On August 14th, 17th and 20th I examined the faeces of these five mice and found no trace of *Hymenolepis* eggs, though heavy infections of *Trichomonas* were present in three of them (*D* 20, *E* 4, *E* 3). I killed the mice on August 20th (13 days after infection) and found all of them to be devoid of *Hymenolepis* infection with one exception, a mouse labelled *E* 1. This, the largest mouse in my collection (a female weighing 35·53 gm. at death), was found to contain in the last 6 cm. of the intestine some five or six young worms all measuring between 5 mm. and 10 mm. in length—a result which in no way threw any light upon previous results. I may remark, incidentally, that these five mice were the largest of the original 34 (they weighed 26·9 gm., 29·3 gm., 31·2 gm., 34·2 gm. and 35·5 gm respectively) and I selected them for this experiment in order to test Grassi's and Joyeux's statements that large mice are difficult to infect. My sole result does not enable me to confirm or to deny these statements.

THE ARTIFICIAL INFECTION OF FIVE YOUNG RATS.

As already stated, I infected on August 7th with the same weak concentration of eggs employed for the 10 mice just described, five young rats between six and eight weeks old. Since I had made no previous examinations of their faeces I cannot guarantee that the two rats which became infected were not previously infected, though it is improbable because they were born in the Bureau Animal House and had been kept under clean conditions and because the other three proved not to be infected. Examinations of the faeces of all five rats on August 14th and 17th showed that *Hymenolepis* eggs were absent on these dates. On August 21st I killed these five rats and found only two to be infected. In one (a female weighing 60·8 gm.) I found a single unsegmented young worm 1·245 mm. long, and in the other (a female weighing 65·6 gm.) I found three young worms (one measuring about 3 mm. and the other two between 4 mm. and 5 mm.) and portions of another.

ON THE EVACUATION OF *HYMENOLEPIS FRATERNA* FROM THE MOUSE.

Since I believe that Joyeux's statements concerning the facility with which mice and rats can rid themselves of *Hymenolepis* have been received with some incredulity in England, I may here again refer to some of the evidence which supports Joyeux's statements. We have seen that although the mice *D* 6, *C* 8 and *C* 9 showed eggs in their faeces on August 5th (16 days after they had been infected) yet on August 8th and 13th when their intestines were examined no mature worms could be found, and, but for the portion of degenerate matured *Hymenolepis* found in the intestine of *D* 12, this mouse also would have been in the same condition. I have found these degenerate eggless matured *Hymenolepis* in several naturally-infected mice as well and they prove that a *Hymenolepis* when once mature often sheds its eggs very rapidly, then releases itself from the intestinal mucosa and becomes cast out as useless. I have frequently observed among the stock of naturally-infected mice which I kept for the artificial infection of the experimental mice that individual mice which are infected (eggs in faeces) on one day become uninfected a few days later. If a mouse be lightly infected the stream of eggs may cease in a few days and not be renewed or only after a considerable period (while the young worms, if present, are arriving at maturity), but in the case of heavy infections the stream may continue for several weeks owing to matured worms being frequently replaced by younger worms. It is thus to the parasite's advantage, as previously indicated, for worms not to develop at a uniform rate and my results certainly seem to show this—a possibility which previous authors have not always taken into account.

I may add here that the mature worm varies greatly in size in different cases. I have repeatedly seen ripe eggs in the proglottids of worms only 6–7 mm. long (*vide D* 18 *e.g.*), even in a mouse (*C* 2) which only contained two worms. Usually the mature worms are small in heavy infections: thus in a naturally-infected mouse harbouring over 100 mostly mature worms no worm exceeded 10 mm. in length; whereas in another naturally-infected mouse harbouring only five worms these were all about 20–25 mm. in length. The number of worms present in an individual mouse is probably a factor in governing the sizes to which the worms grow. I have not yet ascertained whether a mouse can or cannot become secondarily infected from eggs contained in its own faeces.

I am indebted to Dr C. M. Wenyon for the suggestion that I should endeavour to confirm or correct the results obtained by Grassi and Rovelli and Joyeux. I am also indebted to him and to Colonel G. E. F. Stammers for kindly checking all the more important results obtained by me and for some helpful suggestions. My thanks are also due to Dr A. C. Stevenson for the examination of some of the mice which died from vitamin B deficiency, and to Mr G. Dudgeon, C.B.E. and to Dr H. A. Baylis for identifying the fleas and lice and the Nematoda met with during the course of the work.

CONCLUSIONS AND SUMMARY.

1. Of 20 mice (previously ascertained to be free from *Hymenolepis* infection for a period of at least 42 days), artificially infected with *Hymenolepis* eggs, only one failed to show definite evidence of *Hymenolepis* infection when examined from three to 24 days after. Of nine control mice none showed infection during a period of at least 53 days and were found to be uninfected when killed. Of five further control mice which were subsequently artificially infected, four were found to be free from infection when killed.

These results prove conclusively that direct infection, *i.e.* the infection of one mouse by ingestion of the eggs laid by the *Hymenolepis* of another mouse, can take place without the intervention of any intermediate host. The one-host account of the life-cycle of *Hymenolepis fraterna* promulgated by Grassi and Rovelli and Joyeux is thus the correct one, though this does not exclude the possibility of the *Hymenolepis* egg occasionally developing into a cysticercoid inside the body-cavity of a flea and undergoing the rest of its development when the flea is eaten by a mouse[1]. I have not ascertained whether or not a mouse can re-infect itself by swallowing *Hymenolepis* eggs contained in its own faeces.

2. *Hymenolepis fraterna* individuals of the same age (*i.e.* developed from eggs ingested at the same time) often but not always develop at very different rates in different mice and in the same mouse. Grassi and Rovelli's statement that *Hymenolepis fraterna* takes from 15 to 30 days to become mature is approximately correct.

Hymenolepis fraterna can become mature, *i.e.* possess ripe eggs in the hind proglottides, when only 6 mm. or 7 mm. long. In cases of heavy infection (*e.g.* 100–200 individuals in a single mouse) the worms probably always remain of small size (ca. 10 mm.) as compared with the worms in light infections where they attain a length of 20–25 mm.

Eggs can be shed as early as the fifteenth and probably on the fourteenth day of development.

3. It is probable that mature *H. fraterna* often sheds all its eggs within a period of a week and often less, the eggless and degenerate worm then being voided in the faeces.

4. In artificial infection of mice definite results can only be obtained with heavily-infected faecal material. Occasionally mice appear to be immune, but, judging from my experiments, such immunity is rare in mice of medium size. I cannot confirm Joyeux's statement that very young mice are most susceptible to infection. Out of some 200 mice examined I found that the smallest and largest mice were least liable to be infected, medium-sized mice supplying all my infected faeces. The largest mouse (over 35 gm.) in my experimental series, on the other hand, became infected with a weak concentration of eggs.

[1] Joyeux failed to infect flea larvae.

RECENT LITERATURE.

Most of the relevant literature up to 1920 is quoted by Joyeux (1920).

Saeki (1920) states that he has fed mice and rats on human *H. nana* eggs with positive results in most cases; that after ten hours oncospheres are to be found in papillae in the upper and middle parts of the small intestine; that cysticercoids are found after four days; that young plerocercoids are free in the hind end of the intestine after five days; that the genital organs are formed in nine days; that ripe eggs are found in 14 days; that eggs appear in the faeces in 16 to 17 days and that the worm becomes evacuated after a month or more. He also states that he directly infected a girl (four years old) and a monkey with the same human *H. nana* eggs.

Chandler (1922), on the other hand, like Joyeux, and Stewart (1916) and others, failed to infect rats with eggs from human *H. nana*, and is of Joyeux's opinion that *H. nana* and *H. fraterna* are physiologically distinct species. The experiments of all these three authors however were on a very limited scale and certainly not conclusive.

Uchimura (1922) confirms Saeki in stating that the eggs of both *H. nana* and *H. fraterna* develop into cysticercoids (and develop further?) in the intestinal mucosa of white rats and that the two species are indistinguishable in all respects.

Finally I may mention that Baylis (1922) suggests that the cysticercoids discovered by Nicoll and Minchin (1911) and by Johnston (1913) in the rat-flea *Ceratophyllus fasciatus* may not be those of *Hymenolepis fraterna* but may appertain to another species of *Hymenolepis*, *H. longior*, which, though very similar to *H. fraterna*, is yet supposed by Baylis to be distinct.

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(*MS. received for publication* 9. IX. 1923.—Ed.)

STUDIES ON THE ANATOMY OF *CIMEX LECTULARIUS*. I.

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(*From the Molteno Institute for Research in Parasitology, University of Cambridge.*)

(With Plate VI and 12 Text-figures.)

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INTRODUCTION.

The anatomy of the bed-bug has been described many times by other writers. There is therefore no intention in the present paper of dealing with more than those parts of the anatomy which have been described incorrectly or insufficiently or have been omitted from the descriptions. Such are the mouth-parts, salivary pump, salivary glands and nephrocytes and with these subjects accordingly this paper deals exclusively.

My thanks are due to Sir W. A. Hamer, Public Health Department, London County Council, for the material of living *Cimex lectularius* which he kindly supplied for this investigation, and to Prof. G. H. F. Nuttall and Dr D. Keilin for valuable suggestions and help in connection with this study. I should also like to thank Mr A. W. Rymer Roberts for assistance in revising my manuscript for the press.

MOUTH-PARTS OF *CIMEX LECTULARIUS*.

The mouth-parts of *Cimex lectularius* like those of the majority of Hemiptera are reduced to two pairs of long stylets and a median three-jointed rostrum or proboscis, which is grooved dorsally so as to enclose the stylets. The latter have already been described by many writers but since there have been many differences of opinion as to their homology, it is my intention to make a few remarks about them.

A pair of stylets originates on either side of the head (Fig. 1) and each pair converges towards the other anteriorly, running on either side of the pharynx.

The external stylets are very slender, pointed, needle-like structures which serve to pierce and lacerate the wound and have each a row of 20 to 21 teeth near the distal end. They run closely applied to the latero-ventral side of the inner pair.

The stylets of the inner pair (*Mx*) are much stouter and longer than those of the outer. They are grooved on the inner side and just in front of the pharynx form, by apposition, two canals dorsal and ventral (Fig. 2, *dc*, *vc*). They are interlocked throughout their length both dorsally and ventrally and are thus held together even when dissected out from the head.

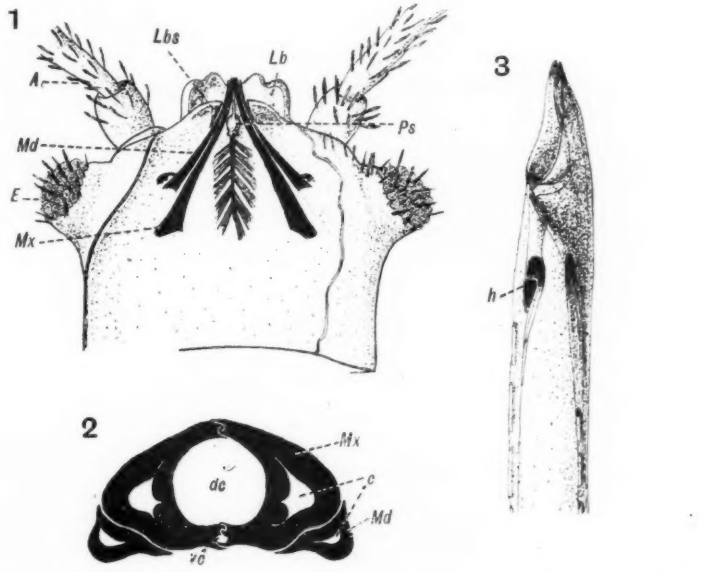


Fig. 1. Head dissected from the dorsal side—Pharynx and Labrum removed. Slightly diagrammatic. ×56.

Fig. 2. Cross-section through the stylets in the region about the middle of the proboscis. ×305.

Fig. 3. Tip of the maxillary tube. ×1066.

A, antenna; *c*, continuation of the body cavity into the stylets; *dc*, dorsal canal; *E*, eye; *h*, hooking arrangement between the maxillae of two sides; *Lb*, labium; *Lbs*, labial strut; *Md*, mandible; *Mx*, maxilla; *Ps*, salivary pump; *vc*, ventral canal or salivary channel.

As seen in the cross-section of the stylets (Fig. 2), the dorsal canal (*dc*) is very much larger than the ventral and is used for sucking blood into the pharynx. Into the narrow ventral canal (*vc*) the fine elongated stem of the salivary pump (Figs. 1, *Ps* and 5, *S*) opens and serves as a channel for the saliva to pass into the wound.

At the anterior end of the pharynx the two pairs of stylets are kept in position by two curved struts (Fig. 1, *Lbs*), which arise from the dorsal side of the labium. The stylets are held pressed against these struts from behind

by the anterior end of the pharynx or the hypopharynx. The labrum completes on the dorsal side the connection between the sucking tube and the pharynx. The opening of the salivary pump (to be dealt with later on) is cut off effectively from the pharynx and the saliva which passes down the narrow ventral canal mixes with the blood of the host before the latter is sucked up through the dorsal tube.

Landois (1868–69), in his description of the mouth-parts, correctly calls the outer pair of stylets the mandibles and the inner pair the maxillae but errs when he says that the sucking tube is formed by all the four stylets, each forming a quarter of the wall.

Patton and Cragg (1913) on the other hand name the outer pair the maxillae and the inner the mandibles, while in describing the sucking tube made practically the same mistake as Landois. In their figure of a cross-section of the sucking tube (Fig. 4, Plate LXII) they represent only the inner pair of stylets and have unfortunately omitted the small outer pair. Probably that is how the mistake arose.

Murray (1914) gives the first correct interpretation of the main outline of the sucking tube as formed by the inner pair of stylets, though he wrongly calls them the mandibles, and does not mention the salivary channel. He also suggests that the stylets of the inner pair, like those of the outer, probably work alternately. This is obviously impossible as the inner stylets have a peculiar hooking arrangement near the end of the sucking tube (Fig. 3, *h*).

The homology of the mouth-parts of Hemiptera with those of mandibulate insects has been the subject of controversy for a very long time. Smith (1892) put forward the view that the two pairs of stylets and the proboscis are all parts of a single pair of appendages, corresponding to the second maxillae of the mandibulate insects. But more recent investigations by Marlatt (1896), Heymons (1896 and 1899), Muir and Kershaw (1911 and 1912), and Davidson (1913 and 1914) have clearly shown that both in Heteroptera and Homoptera the inner or posterior pair of stylets and the outer or anterior pair represent respectively parts of the first maxillae and the mandibles while the proboscis represents the second pair of maxillae of mandibulate insects.

The mouth-parts of the bed-bug resemble those of the other Hemiptera-Heteroptera both in form and position and there is no doubt that the outer or anterior pair (Fig. 1, *Md*) of stylets are the mandibles and the inner or posterior pair (*Mx*), which form the sucking tube, are the maxillae.

SALIVARY PUMP.

The salivary pump has been observed in nearly all the Hemiptera except the Anoplura and a number of writers have already described it in some detail. According to Awati (1914) we owe the discovery of this organ in *Cimex* to Landois (1868–69) but I have not been able to trace any reference to it in his treatise "Zur Anatomie der Bettwanze" which Awati cites in his bibliography.

The structure and the position of the salivary pump found by me in *Cimex*

lectularius are similar to those of *Cimex rotundatus* as described by Patton and Cragg (1913). But the description and the figures of these two authors are not sufficiently complete and I therefore propose to describe the organ here in more detail.

It is a cup-shaped chitinous structure (Figs. 4, 5 and 6) attached to the ventral side of the hypopharynx (Fig. 7, *Hy*) and is about one-tenth the size of the pharyngeal pump[1]. Its broad posterior end is closed by an elastic membrane (Fig. 5, *PW*) which is invaginated into the cup, forming there a strongly chitinised piston (*P*, Figs. 4, 5, and 6). Posteriorly the piston is continued into a flattened rod (*r*) to which on both sides are attached retractor muscles (*m*) running obliquely. The salivary duct opens into the pump on the ventral side, near its anterior end, by a crescent-shaped opening (*O*). The thin posterior border (*V*) of this aperture acts as a valve allowing the salivary secretion from the duct to enter the pump but not to flow back into the duct. The pump is continued anteriorly into a long narrow tube or stem (*S*), which enters the salivary channel (*vc*, Fig. 2) or ventral canal formed by the coalescence of the two maxillae and runs inside this canal for a short distance. The dorsal wall of this tube is very much thinner than the ventral, which is strengthened by a flat thick rib running longitudinally.

Kershaw (1911) in *Pristhesancus papuensis* and Tower (1914) in *Anasa tristis* have described a valve at the opening of the salivary duct into the pump, but the latter also describes another valve guarding the base of the stem. I have not been able to see any valve either in this position or at the distal end of the stem in *Cimex lectularius*, and I think that the return of any saliva or air into the pump from the direction of the stem, when the piston is drawn back, is probably stopped by the collapsing of the thin dorsal wall of the stem.

While describing the working of the salivary pump of *Cimex rotundatus* (which he studied only from sections) Cornwall (1923) says, "When these muscles contract a negative pressure is established in the hollow of the cup by deformation of the elastic chitin and saliva is sucked into the cavity..." of the pump. He goes on to say that "When the muscles relax the elastic chitin slaps back into position and exerts pressure like a piston on the saliva in the cup and forces it out through a canal at its anterior end which terminates just where the mandibles approach one another..." but he does not explain to which particular part of the pump this elastic chitin belongs.

The saliva in *Cimex* is pumped out by the piston (*P*) coming into position, due to the elastic recoil of the posterior membrane when the muscles relax[2].

[1] Murray (1914), probably misled by the somewhat diagrammatic figures of Patton and Cragg (1913), has vainly tried to explain the structure of the pump described by these writers, saying that it is not a separate structure but only the oesophagus drawn into the pharynx. The salivary pump is only about one-tenth the size of the pharyngeal pump and lies ventral to it, near its anterior end. It can in no case be confused with the oesophagus or the crop or any other part of the alimentary canal.

[2] A similar mechanism of the salivary pump has been previously described by Nuttall and Shipley (1903) in *Anopheles maculipennis*.

Fig. 6, which represents the salivary pump in *Cimex lectularius* as seen with its piston drawn out, explains clearly how the pump works. Pressure on the cover-slip has put the pump into the same condition as the contraction of the retractor muscles would have done in life.

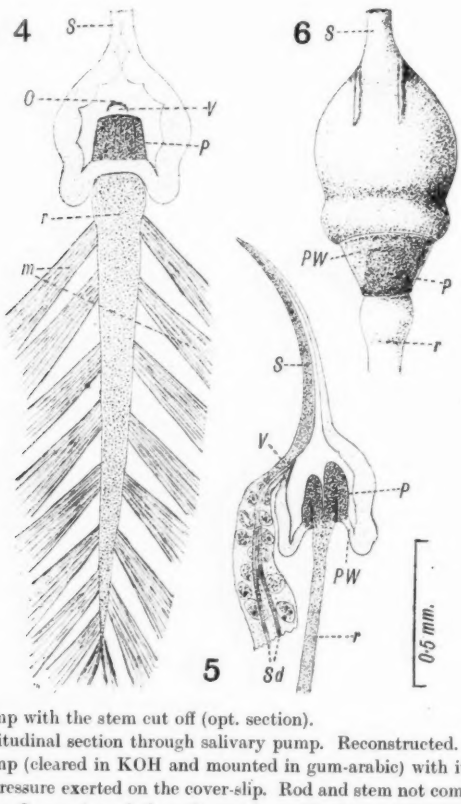


Fig. 4. Salivary pump with the stem cut off (opt. section).
Fig. 5. Median longitudinal section through salivary pump. Reconstructed.
Fig. 6. Salivary pump (cleared in KOH and mounted in gum-arabic) with its piston drawn out through slight pressure exerted on the cover-slip. Rod and stem not completely shown.
m, retractor muscles; *O*, opening of the salivary duct; *P*, piston; *PW*, posterior wall; *r*, rod; *S*, stem or the anterior continuation of the pump; *Sd*, salivary ducts; *V*, posterior border of the salivary opening, acting as a valve.

SALIVARY GLANDS.

We owe to Landois (1868–69) the first detailed description of the salivary glands in *Cimex lectularius*. According to this author they are composed of the four following kinds of glands:

1. *The large spherical or oval salivary glands* lie in the thoracic region on each side of the oesophagus. The duct arising from the anterior end of the gland divides into two branches which run together into the head. One of these branches from either side opens in the angle formed medianly by the

mandibles and maxillae, while the second bends backwards and opens into the stomach.

2. *The small spherical salivary glands* lie one on each side of the stomach and are each provided with a single duct which runs forwards and opens into the "Kropf" (pharynx).

3. *The tubular salivary glands* lie near the small spherical salivary glands and open into the "Kropf." According to Landois they are recognised by their rhythmical contractions.

4. *The branched salivary gland* is a very minute structure consisting of short branching tubules lying on the oesophagus into which it opens directly.

Patton and Cragg (1913) described the first and the second pair of Landois' salivary glands respectively as the ovoid and the cardiac glands. They have shown that of the two daughter ducts from each of the ovoid glands, one meets its fellow of the other side and the duct formed by the union of the two then enters the salivary pump. They were unable to follow the other two ducts of the ovoid glands nor those of the cardiac glands. They were not able to trace the two other kinds of salivary glands (third and fourth) described by Landois.

Murray (1914) for the first time traces the second duct of the large glands and shows that, after running forwards for a short distance, it bends round, runs backwards and ultimately opens into the small salivary gland of its own side.

In a recent paper Cornwall (1923) has described the salivary apparatus of *Cimex rotundatus*. He says that the efferent duct from the pear-shaped glands arises laterally and divides into two branches: one branch goes forwards to meet its fellow of the other side, while the other bends backwards (his figure shows it bending backwards immediately) and becomes the duct of the posterior or the cardiac glands (his Fig. 3, Plate XXXIII). It can, however, be clearly seen from the description and figures of Patton and Cragg, although incomplete in some respects, that the structure of the salivary apparatus in *Cimex rotundatus* is similar to that of *C. lectularius*. It appears therefore that Cornwall's description of the salivary apparatus of *C. rotundatus*, which partly corroborates Murray's observations on *C. lectularius*, is incorrect in that various portions of the salivary apparatus are represented as displaced during dissection.

The salivary glands with their ducts can easily be pulled out by separating the head of the bug from the rest of the body, but this method of dissection[1] is very defective in so far as the relative position of the glands and their ducts with regard to the other organs is concerned.

It is easier to dissect out the salivary glands retaining the other organs intact, in a preserved specimen than in a living one. The following method was used:—With a sharp razor a slice was cut off each side of the head and prothorax, holding the bug between the thumb and forefinger. The specimen

[1] The method suggested by Patton and Cragg.

was then placed in weak alcohol and the dorsal chitinous covering of the anterior part of the body slowly removed, following meanwhile the ducts of the glands up to the point where they reach the supra-oesophageal ganglion. Having turned the bug on its back, the rest of the dissection was completed from the ventral side. Following this method it is also possible to dissect out the salivary apparatus of a living bed-bug, although with greater difficulty. In dissections thus prepared I was able to see the complete structure of the salivary glands and their relation to the other organs surrounding them.

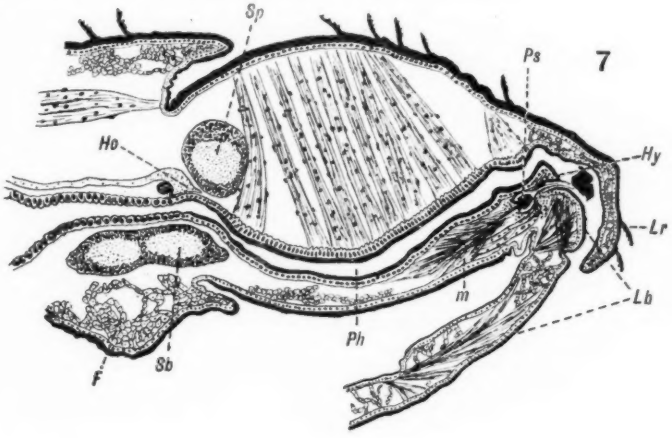
The pear-shaped or anterior glands (Fig. 8, *Pg*) lie one on each side of the oesophagus between the pro- and meso-thorax, and never partly anterior to the supra-oesophageal ganglion (as Cornwall says) which lies almost completely in the head. The efferent duct arising from the broad anterior end of the gland, soon divides into two equal branches which run forwards and bending slightly inwards approach the two branches of the other side just behind the supra-oesophageal ganglion (*Sp*). From this point they turn outwards and, passing externally to the lateral-nerve commissure, enter the head. Here they lie ventral to the pharynx and after a short course the two branches in either side of the head part from each other. The inner branches run forwards and uniting on the median line open into the salivary pump, while the outer branches bend round and running backwards become the ducts of the cardiac or posterior glands (*Cg*) which lie on either side of the stomach.

The discovery of the duct connection between these two kinds of glands brought Murray to the conclusion that the large pear-shaped glands are only the reservoirs while the small spherical ones are the glands proper. However, in examining sections of these glands I find that the wall of the large glands is fairly thick and the structure of its cells shows a much greater resemblance to glandular cells (with large nuclei) than to the flat pavement cells (with small nuclei) which one would expect to find in the wall of a reservoir. Moreover, the study of the contents of these two pairs of glands, as we shall presently see, corroborates the view that both pairs have a true glandular function.

A casual examination of the contents of the two pairs of glands shows that they are not of the same consistency and colour. The secretion in the small glands is colourless and watery while that in the pear-shaped ones, has a deep yellow or terra-cotta colour and is slightly thicker than the former.

Twenty-five of the large and an equal number of the small glands were broken up separately in two watch-glasses with a drop of normal saline solution in each. Each of these emulsions was then mixed with two drops of fresh human blood in a capillary tube. It was observed that the blood with the emulsion of the small salivary glands had coagulated in *twenty to thirty* minutes, while that mixed with the emulsion of the pear-shaped ones had not coagulated after *twenty-four* hours. The control containing fresh human blood mixed only with normal saline solution had coagulated in ten to fifteen minutes. This experiment, even after taking into consideration the difference in the

relative sizes of the two glands, clearly indicates that the secretion of the large glands is very much richer in anticoagulins than that of the smaller ones.



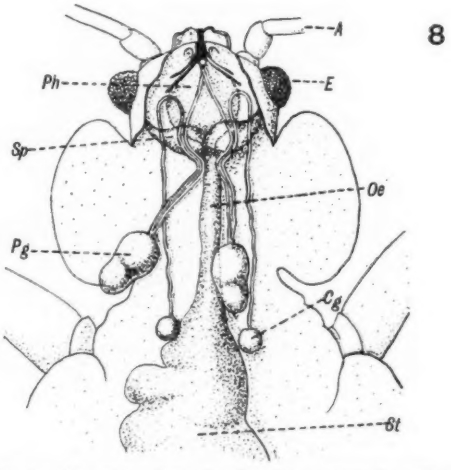


Fig. 7. Median longitudinal section through the head and a portion of prothorax (slightly reconstructed). ×86.

Fig. 8. Dissection of the anterior portion of the body (reconstructed) showing the salivary glands and their ducts. ×30.

A, antenna; *Cg*, cardiac salivary glands; *E*, eye; *F*, fat body; *Ho*, anterior end of the dorsal vessel; *Hy*, hypopharynx; *Lb*, labium; *Lr*, labrum; *m*, retractor muscles of the salivary pump; *Oe*, oesophagus; *Pg*, pear-shaped salivary glands; *Ph*, pharynx; *Ps*, salivary pump; *Sb*, suboesophageal ganglion; *Sp*, supraoesophageal ganglion; *St*, stomach.

By pricking my forearm with a sterilized needle, on the point of which was the crushed salivary gland of a bed-bug, and trying each pair of glands

separately, I found that either of them produces a similar irritation to that felt after the bite of a bed-bug. In both cases the lesion could be seen for about a fortnight, while when the prick was made with a clean sterilized needle, nothing was visible after the second or third day.

The salivary apparatus of the whole group of Hemiptera (Dufour, 1833) shows in main outline, a similar structure to that found in *Cimex lectularius*, but in the great majority the anterior pair of salivary glands, each with two ducts, is branched or lobed and partly composed of a compact mass of cells, while the posterior pair is vesicular. The structure of the salivary glands in the bed-bug is in no way exceptional, as among the other Hemiptera one can find a complete series of transitional forms between those having branched and partly solid anterior glands and those which show a vesicular and pear-shaped structure such as is found in *Cimex*. Bordas (1905) in *Notonectidae* and *Gerridae* and Kershaw (1911) in the case of *Peisthesancus papuensis* and *Enectus elongatus* describe the anterior pair as the true salivary glands while they consider the posterior pair as reservoirs. They state no reason to support this view, and it seems very improbable that the secretion from the gland should flow into the reservoir and from there make its way back into the gland to reach the salivary pump.

From the considerations enumerated above it follows that the two pairs of glands in the bed-bug (and possibly in some other blood-sucking Hemiptera also) are real glands secreting two different kinds of saliva; that secreted by the small glands is thin and colourless and is very poor in anticoagulins while that from the large glands has an orange yellow colour and is very rich in anticoagulins. The small salivary glands pour their secretion into the large glands, where the two kinds of saliva are mixed together and then make their way into the salivary pump.

Landois' fourth type of salivary glands is dealt with hereafter in the section treating of nephrocytes.

NEPHROCYTES OF *CIMEX LECTULARIUS*.

Nephrocytes may be defined as excretory cells having no communication with the exterior parts of the animal, and which accumulate the products of excretion in their protoplasm throughout their life. This name was first given by de Ribaucourt to the excretory cells found in the coelomic cavity of Oligochaetes and by Bruntz (1903) for analogous cells in Arthropods.

They are often intermingled with the fat-body from which under ordinary circumstances they are not easily distinguished and in dissections may be mistaken for the latter. They have even been referred to as other organs, as for example, by Landois, who in *Cimex* considered them to be salivary glands. These cells and their excretory function can however easily be detected by injections into the perivisceral fluid of various substances (ammonia-carmine, indigo-carmine, methylene blue, silver salts, or litmus blue), which they take up and store in their protoplasm without staining the latter.

We owe the discovery of this method of intra-coelomic injection to Kowalevsky (1886, 1889, 1892) who by following it found the existence of such cells in various groups of animals. He showed that these cells have an acid reaction and are capable of eliminating certain soluble substances introduced into the body cavity, while the insoluble ones are taken up by the leucocytes. Working on the same lines, Cuénot (1896), Metalnikoff (1902), and Bruntz (1903) confirmed the results of Kowalevsky on a number of insects and other animals, Keilin in 1917 added a large number of dipterous larvae of various families to the already existing list and Nuttall and Keilin (1921) described the nephrocytes in *Pediculus humanus*.

By feeding insects upon certain coloured substances, some authors obtained results similar to those attained by the injection method. But the feeding method can not be used in the case of blood-sucking insects and injection is the only satisfactory means of studying the distribution of their nephrocytes.

The method of injection into the perivisceral fluid is very delicate and great care is needed to avoid perforating the intestine. The amount of fluid to be injected varies with different insects and can only be determined by experiment.

Of the various substances used by the previous writers on the subject, I selected ammoniacal carmine for the study of the nephrocytes of the bed-bug, but in addition to this I tried "light green" which also gave very good results. The one interesting point about the latter substance is that when it is taken up by the nephrocytes it becomes slightly yellowish[1], thus showing the acid reaction of these cells. All the injections were made in one of the intersegmental regions of the abdomen.

The distribution of nephrocytes was studied only in specimens, which survived for twenty-four hours after the injections, and which did not show any trace of ammoniacal carmine or light green in their perivisceral fluid. The majority of the injected specimens survived the treatment, living a considerable length of time and behaving like the untreated individuals, larvae moulted as usual and the females laid eggs which hatched out in due course. One of the bed-bugs was dissected fifteen days after injection and its nephrocytes were still found to be full of carmine granules.

The nephrocytes of *Cimex lectularius* can be separated into three groups according to their position: (1) Peri-oesophagael, (2) Pericardial, and (3) Parietal nephrocytes.

(1) *Peri-oesophageal nephrocytes*:—These cells correspond in position to the "Guirlandenförmiger Zellenstrang" of Weismann (1864) or the "Néphrocytes ventraux" of Keilin (1917) and the name used here was first given by Nuttall and Keilin (1921) to similar cells found in *Pediculus humanus*. These nephrocytes form two chains one on each side of the oesophagus (Pl. VI, Figs. 11 and 12, *PN*), attached to the anterior end of the dorsal vessel[2] by means of

[1] Light green becomes slightly yellowish when acid (HCl) is added to it.

[2] The open anterior end of the dorsal vessel is slightly dilated and lies just behind the supra-oesophageal ganglion (Fig. 11). The border of the opening, which is directed ventrally, bears

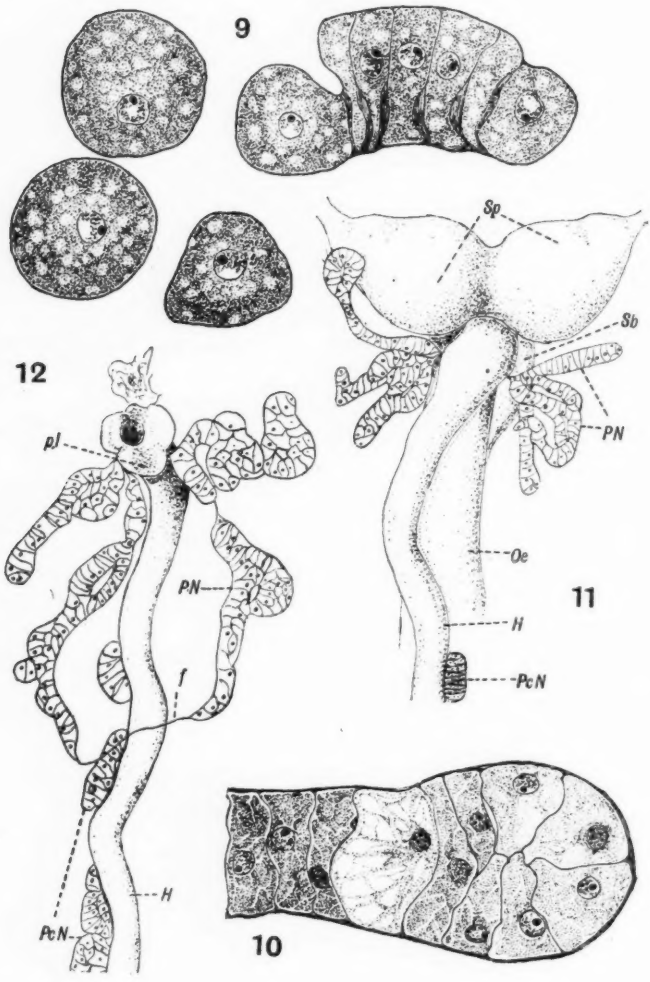


Fig. 9. Peri-oesophageal nephrocytes in section, fixed in Carnoy and stained with Iron-haematoxylin. × 1066.

Fig. 10. Peri-oesophageal nephrocytes *in toto*, fixed in Schaudinn and stained with Haemalum. × 830.

Fig. 11. Part of the dissection showing peri-oesophageal nephrocytes *in situ*. × 100.

Fig. 12. Heart dissected out with peri-oesophageal nephrocytes (as seen from the ventral side). × 100.

f, filamentous connection between the chains of two sides; *H*, dorsal vessel; *Oe*, oesophagus; *PcN*, pericardial nephrocytes; *pl*, posterior lobe of the anterior opening of the dorsal vessel; *PN*, peri-oesophageal nephrocytes; *Sb*, sub-oesophageal, and *Sp*, supra-oesophageal ganglion.

fine connective filaments. The chains of the two sides are usually connected with each other by a similar filament (Fig. 12, *f*) running below the oesophagus and sometimes attached to its ventral side. The shape and the length of the chains are very variable. They are often branched or lobed and occasionally attain considerable length through the elongation of the filamentous connections uniting the groups of cells which compose the chain. In one case the chain of one side was observed to be extended into the mesothorax and, passing underneath the thoracic ganglion, to end in the femur of the second leg.

The number of cells comprising this group of nephrocytes is not constant and the cells are not equally distributed on the two sides. On an average there are about 128 cells in all, the highest number counted being 201 and the lowest 93.

These cells are more or less rounded in form, slightly drawn out where the filament is connected. In those parts of the chain where the cells are not separated by connective filaments the cells have the appearance of flat discs (Fig. 9) placed side by side closely applied to each other. In sections there appear spaces between the cells but these are not seen in the living tissue and are apparently caused by fixation.

Each of these nephrocytes is a uninucleate cell with very granular protoplasm. The nuclei, like those of the other tissues of the body, are vesicular and very poor in chromatin, which is unevenly distributed in them. Living cells show a number of greenish yellow droplets of various sizes.

(2) *Pericardial nephrocytes* (*Pericardial cells*):—This group is composed of a large number of cells attached to the sides of the dorsal vessel, and also distributed along the alary muscles. Anteriorly they begin in the pro- or meso-thorax and form two regular rows of cells, which become more numerous in the region of the alary muscles and spread laterally over them. Around the posterior portion of the dorsal vessel they form a large mass of cells, which can be seen even with the naked eye in a dissected specimen (Pl. VI, *PcN*).

These cells are also uninucleate and show the same structure as the peri-oesophageal nephrocytes, except that they are smaller in size.

(3) *Parietal nephrocytes*:—This group of nephrocytes (Pl. VI, *PrN*) is formed of a small number of cells and is visible only in injected specimens or in sections. It lies just beneath, and touches, the scutellum near its posterior border as a more or less loose mass of cells linked to one another by fine connective filaments. The whole mass is invariably attached to the dorsal vessel by means of a connective filament.

The number of nephrocytes in this group varies between 50 and 80 and, except for their very much smaller size and more or less spherical shape, the cells have the same structure as those described under (1) and (2).

three rounded projections (Fig. 12)—two anterior and one posterior. These projections lie spread out and flattened against the dorsal wall of the oesophagus and it is to the posterior projection that the peri-oesophageal nephrocytes are connected.

It is quite probable that this group of nephrocytes corresponds to Landois' fourth kind of salivary gland, which he states is very difficult to see. I have not seen any independent pulsating movement in this or in the other groups of nephrocytes, but the movement caused by their connection with the dorsal vessel may have misled Landois in his observation.

Nephrocytes of Cimex lectularius *compared to those of other insects*:—Among Dipterous larvae, according to Weismann, Kowalevsky, Pantel, Bruntz, and Keilin, the nephrocytes can be separated into two main groups. The first is ventral to the oesophagus, suspended between the two salivary glands, and forms a crescent-shaped chain of cells ("Guirlandenförmiger Zellenstrang" of Weismann or the "Néphrocytes ventraux" of Keilin), while the other group is distributed along the dorsal vessel in the form of two parallel rows of cells which form the pericardial cells in the strict sense. The nephrocytes of *Pediculus humanus* also form two groups (Nuttall and Keilin, 1921)—the anterior group, corresponding to the first group of nephrocytes in Dipterous larvae, lies on either side of the oesophagus and has been termed the *Peri-oesophageal nephrocytes*; while the cells comprising the other group of nephrocytes are scattered all over the body and have been called by them *Disseminated nephrocytes*. In *Haematopinus eurysternus* (see Sikora) the second group of nephrocytes, instead of being disseminated as in *Pediculus*, is localised along the dorsal vessel and forms real pericardial cells. In Mallophaga the distribution of the nephrocytes into two groups is similar to that in *Haematopinus*.

The first two groups of nephrocytes of *Cimex lectularius*—the peri-oesophageal and the pericardial, correspond to the two groups found in Dipterous larvae, while the third group (parietal nephrocytes) most probably represents some of the disseminated nephrocytes of *Pediculus humanus*. It may be that the distribution of nephrocytes in *Cimex lectularius* shows a transitional stage between that found respectively in *Pediculus humanus* and in *Haematopinus eurysternus* and various other insects.

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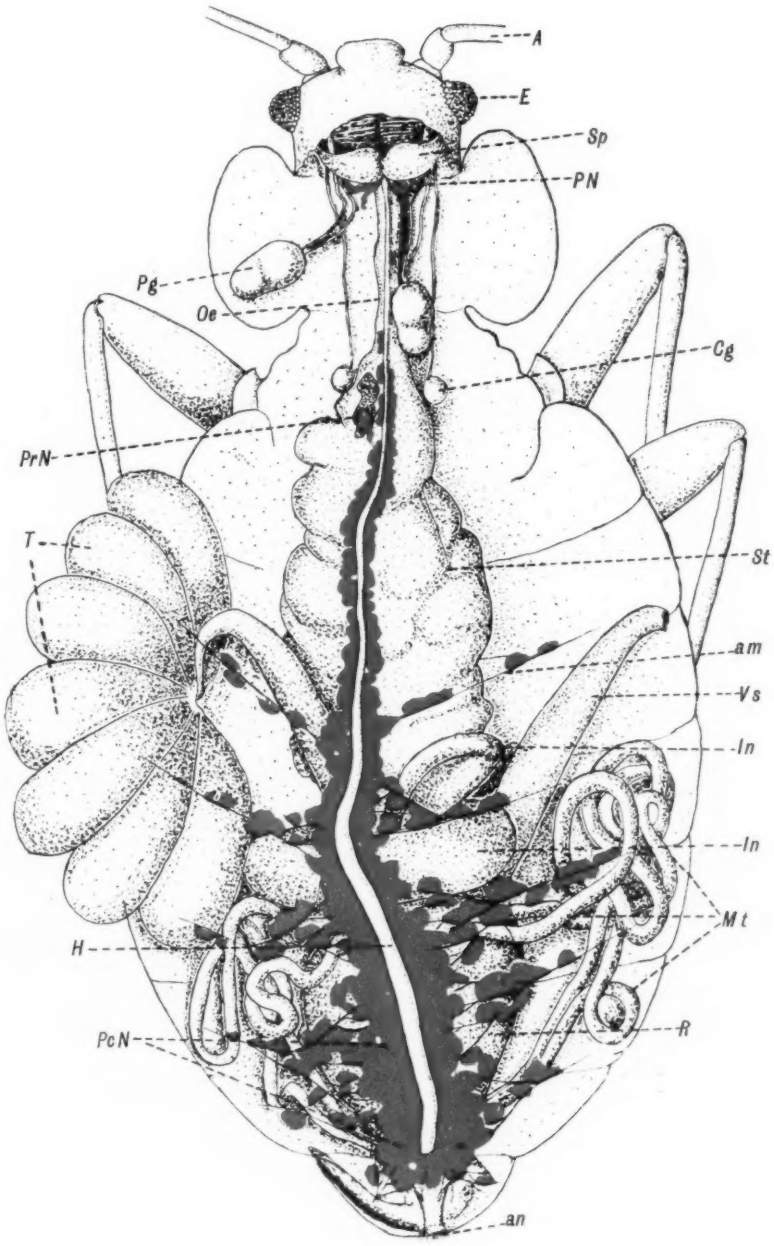

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EXPLANATION OF PLATE VI.

Dissection of a male *Cimex lectularius*, about 30 hours after injection with ammoniacal carmine, showing the nephrocytes charged with carmine granules. ×34. *A*, antenna; *am*, alary muscle; *an*, anus; *Cg*, cardiac salivary glands; *E*, eye; *H*, dorsal vessel; *In*, intestine; *Mt*, malpighian tubules; *Oe*, oesophagus; *PcN*, pericardial nephrocytes; *Pg*, pear-shaped salivary glands; *PrN*, parietal nephrocytes; *R*, rectum; *Sp*, supra-oesophageal ganglion; *St*, stomach; *T*, testes; *Vs*, vesicula seminalis.

(*MS. received for publication* 22. IX. 1923.—Ed.)

ON THE MIGRATION OF *HYPODERMA LINEATUM* FROM THE SKIN TO THE GULLET.

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(With Plate VII.)

On June 10th, 1923, a practising veterinary surgeon brought into the Pathological Laboratory at the University scrapings that he had obtained from a herd of cattle which were suspected of being mangy. The sample was examined for mites without success. The veterinary surgeon said that the lesions were not typical of mange, but if it was not mange, it was some form of dermatitis which was unknown to him.

A visit was paid to the herd and an examination made of the animals. It was found that the lesions were those of hypodermal rash and the empty egg-shells of *Hypoderma lineatum* were discovered on the hairs overlying some of the lesions. Hypodermal rash has confused veterinary surgeons on other occasions, the lesions having been mistaken for cowpox and other forms of dermatitis.

Warburton (1922) gives a summary of our present knowledge of the life history of warble flies, drawing attention to certain lacunae which remain to be filled.

The opportunity seemed favourable for further research and the following facts have been gathered:

The Migration of the Newly Hatched Warble Grub from the Skin to the Gullet.

Warburton (1922) writes: "During the autumn and winter months (in England) the larvae, entirely lost sight of since their penetration of the outer integument, reappear with great regularity in the wall of the oesophagus, in the connective tissue beneath the submucosa. How they reach this position is entirely unknown."

The larvae begin to appear in the oesophageal wall in September (in England) and Warburton states that there may be larval stages intermediate between the smooth oesophageal instar and the spiny instar. He quotes Laake, 1921, who has described one such intermediate form. Laake says in speaking

of the second stage: "This new stage is unlike the small heavily armed larva which hatches from the egg, or the larger spineless larva that is later found in the oesophagus, or on the back before moulting to the next spiny stage formerly known as the third stage."

Both Laake and Warburton have evidently overlooked the brief statement made by both Carpenter and Hadwen (1912) who mention finding five larvae in the oesophagus of a calf on August 15th, measurements being as follows: 3·4 mm., 4·0 mm., 4·8 mm., 3·8 mm. "The larvae are similar to those mentioned by Carpenter as being observed by continental writers, they are, however, quite different from the second stage described by some writers in having rows of minute spines on the segments."

Judging from our tabulated measurements (see pp. 102–105) which record the finding of numbers of larvae, both in the walls of the oesophagus and outside it, it is probable that the migration of the larvae from the skin to the oesophagus is quite rapid. The measurements are given in all cases showing that when the larvae reach the chest cavity, they are quite small and in some cases, barely twice the size of the newly hatched larva. One undoubted first-stage larva was found in the oesophagus and several more very small larvae, which are possibly first-stage forms that have undergone an extension of the integument during their growth, consequently causing a wider separation in the rows of spines.

The character and arrangement of the spiny armature have not been studied fully in the present investigation, but it appears to correspond very closely with what has been described by Laake (1921). The specimens are now in Mr Warburton's hands for further study and comparison with the material he has in his collection.

In the post mortem examinations held in Saskatoon, no larvae were found under the skin. It is believed that if the examinations had been made a little earlier, larvae would have been discovered, but the season had advanced too far and only the lesions caused by the grubs in their passage were found. *H. bovis* had not appeared in June or early July, consequently the remarks which follow apply only to *H. lineatum*. The lesions which were present are so characteristic for *Hypoderma* as to leave no doubt that the route followed by the larvae has been approximately traced. These lesions will be described more fully in the paragraph on pathology (see p. 100).

Wherever the eggs are laid (the regions being now well known, Hadwen, 1916, and others) the underlying tissues show the tracks followed by the larvae. These are very plain in the tissues, around the heels between the sesamoid bones, and up the tendons to the knees or hocks. They are plainly visible at the elbow joint, in the patellar region, and in some cases further up the legs. In the abdominal cavity, the first definite tracks were found at the attachment of the diaphragm at the posterior extremity of the sternum. Larvae were found on the peritoneal side of the diaphragm where they sometimes appear to take a wrong course. Some of them migrate posteriorly and two larvae were secured

about 15 cm. down the duodenum. Other larvae, instead of entering the oesophageal submucosa at the diaphragmatic end, remain outside and wander up to the cardiac region. It is possible some of the larvae found here came from the anterior limbs. This has not yet been proved. In one instance eleven larvae were found in the pericardial sac and four were actually on the heart itself. The large number of grubs discovered in transit from the skin to the oesophagus in Case 10 shows that the migration was interrupted during its progress. Further examinations are necessary a little earlier in the season to establish the whole course of migration.

Knowing that the larvae follow the path of least resistance through the connective tissue, it will be comparatively easy to discover them, especially as there are only certain routes which would lead them to their destination. For instance, an almost certain track for them to follow from the hock to the abdominal cavity would be along the sciatic nerve over the top of the femur to the sacrum where there is nothing to prevent the larvae getting under the peritoneum.

Of great assistance in tracing the larvae are the yellow oedemas which surround them. When an oedematous patch was noticed, one or more larvae was almost invariably found.

Pathology.

In previous articles, Hadwen (1916) has described the skin lesions which follow the penetration of the grubs. It was remarked that no appreciable lesions occurred on the leg below the knee and hocks. While this is true about external appearances, it is not true about the subcutaneous tissues. In all post mortems held this spring, except in young animals, striking lesions were encountered under the skin on the legs, especially severe above the heels and in the triangular space above the sesamoid bones. Why these lesions do not show externally may be explained by the fact that the skin is very thick and tight on the legs, so that the inflammation subsides without coming to the surface, or else it is forced downward or upward. Veterinary surgeons have noticed lamenesses in cattle during the warble season which may be attributed to this cause.

The above supposition needs further confirmation, but if it is permissible to argue from observations made in other animals such as reindeer, dermatitis is quite common around the hocks and knees following the penetration of *Oedemagena tarandi* and is occasionally seen lower on the legs. In this animal the skin is thin, just as it is in cattle above the hock where most of the lesions are encountered. The defensive reaction against the grubs is manifested by an oedema and an outpouring of serum. As the oedema subsides a scab covers the skin and when this is lifted off, conical pits filled with greenish pus are found. The leucocytes in the pus consist almost wholly of eosinophiles (up to 80–90 per cent.). It has been definitely established that the eosinophile assumes a phagocytic rôle in presence of the infested fluid and picks up debris and bacteria. No doubt other factors enter into the case and that the reaction is

not wholly phagocytic. In some unpublished notes made several years ago precipitin tests were described which proved that the serum of uninfected animals gave no reaction, but that of infected ones did so in dilutions of 1 in 200.

Bacterial Infections.

As warble grubs bore through the skin in those regions that come in contact with the soil, diseases like blackleg and anthrax might be inoculated by the larvae in their passage through the skin. No experiments have as yet been made to prove or disprove this hypothesis. In the case of reindeer, Hadwen (1922) has shown that infections with *B. pyocyaneus* are common. In the present studies, no further facts have been encountered except that it has been definitely shown that the larvae reach the thoracic cavity in a sterile condition. Six larvae were extracted from the tissue of the gullet and dropped into bouillon tubes which were incubated. Five of the tubes remained sterile, the contamination of the sixth no doubt being accidental. It is quite evident the larvae could not be infected when they reach such places as the pericardium, otherwise there would be many deaths during the warble season.

Immunity to Warble Grubs.

In experiments made in 1918, ten new-born calves were injected with warble juice and three of these showed a marked sensitization, exhibiting all the symptoms of anaphylaxis. The seven remaining animals showed no reaction worth recording. Therefore it would seem that a large percentage of calves offer no resistance to the larval penetration. This is borne out by field observations.

It has been stated by Warburton that yearlings are more subject to attack than calves. This might easily be expected because many calves are born at a time of the year when there are no warble-flies, or are stabled during the warble season. All veterinary surgeons are agreed that two-year-olds suffer most from warble grubs. It is after this age that skin reactions are most marked.

In the present investigation it was found in several instances in the older animals that although the skin and subdermal lesions were well marked and characteristic of warble infestation yet no grubs were discoverable either outside of the oesophagus or under the mucous coat. It seems, therefore, that the immunity that develops in the older cattle is effective in the prevention of warbles. In future experiments, attempts will be made to assist the process of immunity by injecting young animals.

Seasonal activity of H. lineatum.

From reports received from farmers, warble-flies were first noticed about May 30th near Saskatoon. On June 10th eggs were collected which were found to have hatched. No flies were captured. The season on the prairies has been unusually wet which may account for the short fly season.

Animal No. 1.

Cow three years old. This animal showed evidence of having had hypodermal rash.

Autopsy, June 15th. There was a serous infiltration above the heel and in the triangular space above and between the sesamoid bones. A serous infiltration into the subcutaneous tissues was observed around the hock, knees, stifle joints and elbows. Oedema was present under the peritoneum, pleura and around the gullet. No grubs were present. In the infiltrated areas there were necrotic spots. In all oedematous areas the eosinophile was the predominating cell.

This case was considered one in which all the grubs had been destroyed, either on their way or upon reaching the gullet.

Animal No. 2.

Heifer just under one year old.

This animal had a few mature warbles on the back. There was no evidence of recent warble infestation and no warble eggs were discovered on the hair.

Autopsy, June 21st, 1923. On skinning the legs gelatinous patches were noticed. The colour of these areas was of a greenish-yellow as was the case in animal No. 1.

At the junction of the peritoneum with the diaphragm a definite yellow track was found surrounded by an oedema. Warble larvae were found both outside and inside the gullet. The length of the gullet was about 57 cm.

Measurements of larvae found in submucosa mm.	Distance from paunch end of the gullet cm.
2·75, 2·0, 3·0	13
3·0, 2·75	16
4·0, 3·25, 3·0, 3·5, 3·0, 3·0	18
3·0	32
2·25, 3·5	37
2·75	47
3·25, 2·75, 3·0, 3·0, 2·75, 3·75	Situation not determined exactly

Number of larvae found, 21. Average length of larvae, 3·0 mm.

Measurements of larvae found in close proximity and on the outside of the gullet, five of which were on the outside of the larynx.

3·5, 3·0, 2·75, 3·0, 3·25, 3·5, 2·75, 3·75, 3·5 mm.

Number of larvae found, 9. Average length of larvae, 3·2 mm.

Eleven larvae were within 13 cm. of the diaphragm. All larvae were considered to be in the second or spinous stage, with the exception of one, which was of the first instar.

Animal No. 3.

Calf seven weeks old.

No traces of larval penetration.

Autopsy, June 25th, 1923.

Very slight discoloration around the heel. Two larvae were found, one inside and one outside of the gullet.

Animals Nos. 4–9.

These were all aged animals with the exception of one, a two-year-old.

Autopsies, June 28th, 1923.

Oedemas were noticed as in the preceding cases. In one animal there was considerable oedema surrounding the oesophagus, quite diffuse towards the lower end, this might have caused serious consequences. Some of the oedemas were large enough to cause an unevenness in the lumen of the gullet and had they developed further might have caused obstruction.

In practically all cases larvae were found in or near the oedema and in some instances were evidently escaping from it, the oedema being drawn out to a point, at the extremity of which the grub was found.

The oedematous fluid contained many eosinophiles and this cell predominated over other types.

Bacteria were only noticed in one case, which may have been an accidental infection after the oesophagus had been removed.

In Animals 8 and 9 there was evidence of larval penetration but none were found. The appended data relate only to Animals 4–7:

Measurements of larvae found in submucosae of gullet mm.	Distance from larynx cm.
4·0, 4·0, 4·0	44–47
4·5, 4·5	47–60
4·5, 4·5, 5·0, 4·5	60–63

Number of larvae found, 9. Average length of larvae, 4·3 mm.

Measurements of larvae found in close proximity and on gullet mm.	Distance from larynx cm.
4·25, 4·0, 4·0	43–50
4·0, 3·75, 4·0, 3·5, 4·25	60–70

Number of larvae found, 14. Average length of larvae, 3·7 mm.

Animal No. 10.

Heifer just under one year old.

No mature warble grubs were discovered on this animal as it had evidently escaped attack the preceding summer.

Autopsy, July 7th, 1923.

On skinning the legs, no definite oedematous areas were observed, but as soon as the body cavity was opened and the entrails removed, a number of oedemas were at once noticed. These were principally around the hiatus oesophagus of the diaphragm and under the serous coats of the diaphragm.

There was one large oedema 8–10 cm. in length on the outside of the duodenum, several on the paunch and attachments of the mesentery.

In the thoracic cavity oedemas were observed on the pillars of the diaphragm and an especially large one along the trachea and oesophagus extending from the diaphragm to a point about 31 cm. anteriorly.

Other swellings, smaller in size, were found on the mediastinum. On the outside of the pericardial sac there were fibrinous deposits and one greenish oedematous area about 5 cm. in diameter and another slightly smaller one. Between the membranes, gelatinous material was found surrounding the warble larvae.

On the covering of the heart there were several small oedematous tracks and some small fibrinous deposits. On the surface of the auricles were several small diseased patches which could not be connected with warble grubs. Around the origin of the pulmonary artery and the aorta were several oedematous tracks in which larvae were found. Especially noticeable was a narrow track extending from the bifurcation of the aorta anteriorly, then downwards for about 8 cm. This track was of a yellowish colour and was streaked with blood.

Measurements of larvae found in submucosa mm.	Distance from paunch end of gullet cm.
4·5, 4·25, 4·0, 4·0, 3·25, 4·5, 4·25	1–5
4·0, 4·0, 3·75, 3·75, 4·0, 4·0, 4·0, 3·0, 3·75, 4·0, 4·25, 4·0	
4·25, 4·0, 3·25, 4·5, 4·5, 4·5, 4·0, 4·0, 3·0, 4·0, 4·0, 4·0, 4·25, 4·0, 4·0, 4·25, 3·25, 3·25, 4·0, 4·75, 4·25	8–10
4·5, 4·5, 4·25, 3·75, 4·25, 3·25, 4·0, 3·0, 4·0, 4·0	10–16
4·0, 3·25, 4·0, 4·25, 4·25, 4·0, 4·0,	16–21
4·25, 4·0, 4·0, 4·5, 4·75, 3·75, 4·75, 3·5	21–31
4·0	37

Total number of larvae, 66. Average length of larvae, 3·9 mm.

Measurements of larvae found in close proximity and on gullet mm.	Distance from paunch end of gullet cm.
4·75, 4·5, 3·75	1–5
3·0, 4·25, 3·5, 3·5, 4·0, 3·5	8–10
3·5, 4·0, 3·5, 3·5, (3·5?)	10–16
3·25, 4·0, 3·25, 4·0, 4·0, 3·5	16–21
3·75, 3·5	40

Number of larvae found, 22. Average length of larvae, 3·5 mm.

Larvae found between membranes of the pericardial sac.

4·25, 3·25, 3·25, 3·25, 3·25, 2·5, 4·0, 3·5, 5·0 mm. (1 broken)

Number of larvae found, 11. Average length of larvae, 3·5 mm.

Measurements of larvae mm.	Situation
4·0, 4·25, 4·5, 4·5, 4·5, 4·0, 4·25	At junction of the pillars of the diaphragm.
4·0	On body of the diaphragm 8 cm. from ribs.
5·0	2 cm. from the entrance of the paunch under serous coat.
3·0	Half-way up trachea.
3·5	Behind pulmonary artery.
4·0	At origin of aorta.
3·5	On anterior aspect of the aorta, 4 cm. above the heart.
4·0	At origin of the pulmonary artery.
5·25, 5·0	15 cm. down the duodenum, under serous coat.

Number of larvae found, 16. Average length of larvae, 4·2 mm.
Total number of larvae found outside the oesophagus, 49.
Average length of larvae found outside the oesophagus, 3·7 mm.
Total number of larvae found inside the oesophagus, 66.
Average length of larvae found inside the oesophagus, 3·9 mm.

Summary of Tables.

The largest number of larvae found was in animal No. 10. 66 larvae were removed from the submucous coat of the oesophagus averaging 3·9 mm. in length. On the outside of the gullet there were 22 larvae with an average length of 3·5 mm. On the pericardial sac there were 11 grubs averaging 3·5 mm. and in other situations 10 grubs averaging 4·2 mm. This makes a total of 115 larvae in this animal. 49 larvae had not yet reached the gullet which clearly shows that the migration was not nearly completed.

In another case there were 21 larvae in the submucosa of the gullet averaging 3·0 mm. and 9 outside the gullet averaging 3·2 mm.

It was hoped the larvae outside the gullet would prove to be smaller than those inside but the difference was slight. However, in case No. 10 there was a difference of 0·2 mm. shown, the larvae outside the gullet being smaller.

It is almost certain that similar results would be obtained in England if examinations were conducted at this season of the year, the warble season in Saskatchewan being even later than it is in England.

CONCLUSIONS.

The condition of hypodermal rash or dermatitis may be mistaken for mange or cowpox.

The warble larvae may reach the oesophagus in the first stage and in the Province of Saskatchewan, Canada, larvae have been found in the oesophagus as early as June 21st. On this date one larva measuring 2·0 mm. was found, and several 2·25 mm. in length.

Twenty-one larvae collected under the submucosa averaged 3·0 mm. in length and 9 larvae found outside the oesophagus 3·2 mm.

On July 7th the average length of the larvae was a little longer, 115 averaging 3·7 mm.

The larvae in the thoracic cavity proved to be sterile. This was proved by removing larvae and incubating them in bouillon tubes.

The eosinophile plays an active part in combating the entrance of *Hypoderma* larvae into the body and acts as a phagocyte in the presence of warble grubs.

Animals become immune to warble grubs when they reach adult life. Following the experimental injection of warble juice into ten calves seven of the animals were not affected and three gave typical anaphylactic reactions. The three calves appeared to have an inherited sensitiveness to the injection of warble juice.

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DESCRIPTION OF PLATE VII.

Fig. 1. Cow showing rash caused by *Hypoderma lineatum* larvae having penetrated the skin. Note the rash high up on the udder and about base of tail. The lesions on the tail had been wrongly diagnosed as mange.

Fig 2. Cow showing rash on udder, due to *H. lineatum*. Such lesions have been mistaken at times for those of cowpox.

(*MS. received for publication* 2. VIII. 1923.—Ed.)

Fig. 2

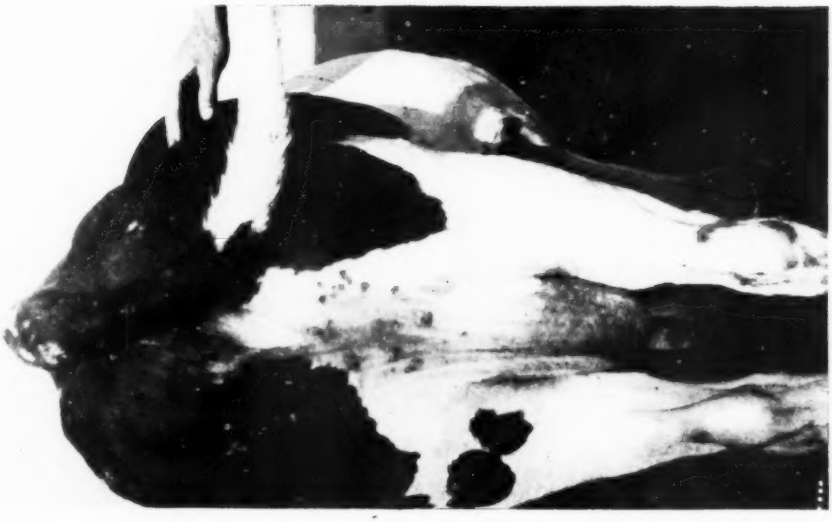

Fig. 1

THEILERIASIS IN GOATS, SHEEP AND CATTLE, WITH A DESCRIPTION OF *THEILERIA HIRCI* N. SP. FROM SERBIA.

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(With 2 Text-figures.)

In the present state of our knowledge, it is difficult to establish the specific identity of the Piroplasmidae that occur in the blood of various animals and it is still more difficult to identify them when found in the same host in different localities. Therefore it is more practical in dealing with such parasites, encountered in different animals, to consider them as separate species, because, by so doing we are more likely to acquire accurate information about them and to avoid confusion.

PIROPLASMIDAE IN SHEEP AND CATTLE.

As examples of the confusion which may arise, we would cite the following observations that have been made on these parasites in sheep and cattle.

Sheep. The parasites of sheep differ in important respects. The form causing Carçeag in sheep in Roumania (*Babesia ovis*) differs from that occurring in Transcaucasia. According to Christophers, the parasites found in sheep in North and South India differ from each other and the forms described from other countries. Again, the parasites found in sheep in East Africa by Schellhose and in Rhodesia by Bevan are classed as belonging to the genus *Gonderia*. Finally, if we accept Inchiostro's description, it would seem as if piroplasmosis of sheep in Dalmatia were caused by a parasite that is specifically distinct. To summarise the position at present obtaining, the four following genera of Piroplasmidae have been described as occurring in sheep in different parts of the world: *Babesia* (in Europe), *Nuttallia* (in Transcaucasia), *Gonderia* (in Africa) and *Theileria* (in Africa and Asia).

In this connection, we may mention that whilst working, during the summer of 1922, with the Antimalaria Commission in Macedonia, we found that piroplasmosis in sheep occurred all over Macedonia, this, strange to say, not having been as yet recorded in any publications we have consulted, although a similar disease has been described as affecting sheep in all the surrounding countries. Piroplasmosis among sheep in Macedonia is unquestionably of great economic importance.

Cattle. The presence of *Theileria* in affected cattle has been recorded in Greece (Cardamatis), Macedonia (Behn), and Bulgaria (Ansheloff). These authors believed that they were dealing with *Theileria parva* but we are of opinion that the parasite was *T. annulata* which we regard as Asiatic in origin.

PIROPLASMOSIS IN GOATS.

The occurrence of piroplasmosis in goats has been recorded in Cameroon (Ziemann), German East Africa (Panse and Schellhose), Transcaucasia (Dschunkovsky and Luhs) and India (Lingard and Jennings) but not hitherto in Europe.

OUTBREAK OF HIRCINE THEILERIASIS OBSERVED IN SERBIA.

We would record the following outbreak in the large village of Negorci, Ghevgheli District, Serbia, lasting from mid-June to about mid-July. Only goats were affected, the peasants inhabiting the village having recently collected there with their herds from various parts of the kingdom. The neighbouring town of Ghevgheli, on the Greco-Serbian frontier, lies in the Vardar River valley and is surrounded by hills, the lowland with its rich vegetation being subject to floods.

Thirty-nine goats were affected of which 18 (46 per cent. died), the rest recovering.

Symptoms. Fever, the temperature attaining 40·5–41° C.; great prostration; great pallor of the visible mucous membranes. Urine cloudy but no haemoglobinuria. Duration, 5–6 days. A relapse appears to have occurred in two cases of which inadequate records were kept.

Autopsy appearances were studied in two cases. The mucous membranes were very pale, the spleen enlarged, the bladder contained clouded urine (no haemoglobin).

THEILERIA HIRCI N.SP. (Fig. A).

Examination of peripheral blood smears showed 35–60 infected corpuscles per field, the parasites occurring singly, in twos, rarely in threes, in the centre of the corpuscles. The parasites were mostly small and distinctly ring-shaped, others being bacillary or nail-like, oval or piriform. The chromatin granules in round and oval forms occurred peripherally, being either rounded (signet-ring appearance) or elongated and occupying a good part of the parasite's periphery; rarely did two closely apposed chromatin granules occur in a parasite. Stained by the Romanovsky or Giemsa methods, the protoplasm appeared pale blue peripherally. Some rounded parasites appeared more uniformly blue. Many extracellular parasites were observed, all were rounded. Rod or nail-like forms are rare. Cross-like forms of parasites occur, each member being piriform. The chromatin in elongated parasites occurs as a more or less concentrated mass either at the broad or narrow end or scattered peripherally. A parasite was once found within a polynuclear leucocyte (see Fig. A, 24).

Elements similar to Koch's blue bodies or "Plasmakugeln" were also encountered in peripheral-blood films. These bodies were round or oval, at times as large or larger than a blood corpuscle, and contained chromatin granules of varying size and shape. We were unable to examine the goats' internal organs with a view to studying the parasites therein, this being un-

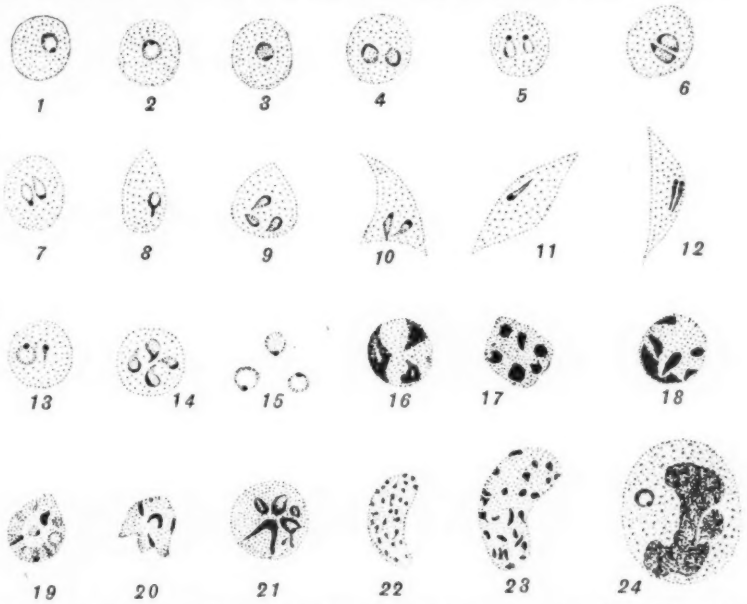

Fig. A. *Theileria hirci* n.sp. illustrating various stages and forms encountered in peripheral blood of goats (Nos. 1–14 are intracorpuscular). Nos. 1–4 rings and ovals, 5–10 piriforms, 11–12 elongate forms, 13 a "signet-ring" and nail-shaped parasites, 15 free parasites or "agamonts," 16–23 "gamonts" (adopting nomenclature of Gonder for *T. parva*), 24 parasite within leucocyte. Redrawn in Cambridge from authors' water-colour figures.

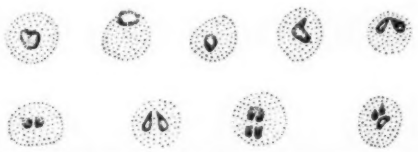

Fig. B. *Gonderia hirci* Dschunkovsky and Luhs. Various intracorpuscular parasites.

fortunate in view of the presence of the "blue bodies" above referred to. Although incomplete, what we have seen leads us to refer the parasite to the genus *Theileria* and we give the new protozoon the provisional name *Theileria hirci*.

Our parasite differs from *Gonderia hirci* Dschunkovsky and Luhs (Fig. B) in form and mainly by the presence of "blue bodies." In the disease caused by

G. hirci, in Asia, we have always observed haemoglobinuria which symptom was absent in our Macedonian cases due to *T. hirci*.

RHIPICEPHALUS BURSA THE PROBABLE CARRIER OF *THEILERIA HIRCI*.

In 1921 ticks were collected in different parts of Serbia from healthy or characteristically affected goats. In all cases *Rhipicephalus bursa* alone was found on the goats. It is highly probable therefore that this tick serves as the vector of *T. hirci*, notwithstanding the following:

Negative Experiment. Two *R. bursa* ♀♀, taken from *T. hirci*-infected goats, were allowed to oviposit. The larvae which hatched were placed on two healthy goats from Skoplje (Uskub), but the goats remained healthy for two months.

Acknowledgments. Our investigations were rendered possible through cooperation between the Serbian Board of Health and Ministry of Agriculture, in furthering the work of our laboratory. We are, moreover, indebted to Mr Oswald Repitch (Chief of Veterinary Station, Ghevgheli) for the ready and efficient help he gave us in obtaining blood films and ticks from infected goats for purposes of study.

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MYIASIS IN *BUFO REGULARIS* CAUSED BY A TABANID LARVA.

By EDWARD HINDLE,

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(With Plate VIII.)

In December, 1922, whilst dissecting a large female example of *Bufo regularis*, one of my students noticed a cylindrical structure extending along the ventral region of the body-cavity. A careful examination showed that this structure consisted of an elongated sac-like diverticulum of the right lung, containing an almost full-grown specimen of a dipterous larva, which could be seen through the membraneous wall of the diverticulum. The base of the latter, in addition to its point of origin from the lung, was also connected to the dorsal surface of the liver by strands of fibrous tissue, suggesting that the growth had been in existence some considerable time in order to cause such adhesions. Posteriorly, the diverticulum hung freely in the body cavity and extended to the extreme hinder end. Its dimensions were 5·5 cm. in length, by 0·5 cm. in diameter, but tapering towards each extremity.

On cutting open the right lung a very fine opening, about 1 mm. in diameter, was found leading into the cavity of the diverticulum. The contained larva filled the entire cavity and was arranged in such a way that its posterior extremity, with the spiracles, was at the base of the diverticulum where it communicated with the lung. The spiracles can be seen in the accompanying plate, as two yellowish protuberances just below the point of attachment of the sac to the lung and liver (*vide* Plate VIII).

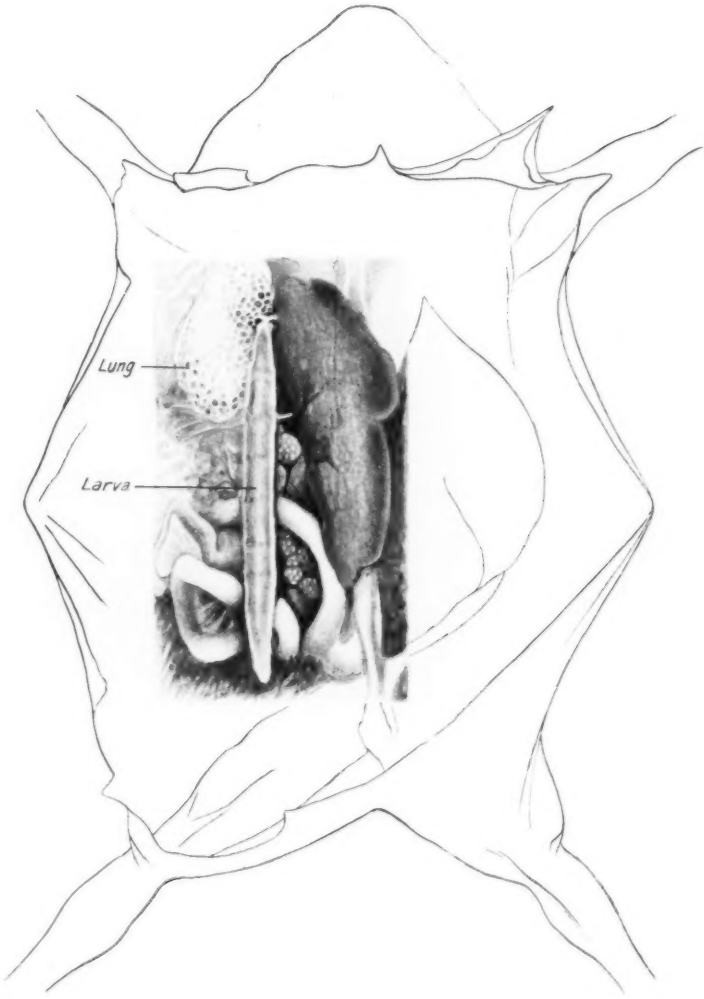
As the toad had been killed by means of chloroform the larva was also dead, but had obviously only just died. It was preserved and sent to my friend Dr Keilin, at the Molteno Institute, Cambridge, and was identified by him as a Tabanid larva. It is well known that these larvae are carnivorous, feeding on other larvae, annelids, molluscs, etc., but so far as I am aware, they have not previously been found living as internal parasites. In the present instance we are evidently dealing with a case of accidental parasitism, and, although more than 600 toads were examined about the same time, no other parasitic larvae of the kind were found. Presumably this toad swallowed a young Tabanid larva which accidentally passed through the glottis into the cavity of the right lung. There its presence seems to have produced the development of the membraneous sac in which it lived, and incidentally no escape from the

sac would have been possible except by rupture of its wall. The case recorded in this note is of interest since it affords another instance showing the adaptability possessed by many species of dipterous larvae, for here we see a larva accustomed to a predatory free-living existence, at once changing its mode of life and becoming an internal parasite.

Note. Surcouf (*Bull. Soc. Ent. de France*, 1923, p. 132) briefly refers to the above-described case of parasitism, but without giving any details. His information was derived from a letter by my friend and lecturer Mr H. C. Efflatoun.

DESCRIPTION OF PLATE VIII.

Ventral view of the internal organs of a female *Bufo regularis*, showing the diverticulum containing a Tabanid larva lying between the right lung and liver, and projecting backwards. (Only the region in the immediate neighbourhood of the diverticulum has been coloured.) Drawn to natural size.



Bufo regularis
With Tabanid larva in situ
(Natural size)

ON THE LIFE HISTORY OF *NEOTTIOPHILUM PRAEUSTUM* (MEIGEN 1826) (DIPTERA-ACALYPTERÆ) PARASITIC ON BIRDS, WITH SOME GENERAL CONSIDERATIONS ON THE PROBLEM OF MYIASIS IN PLANTS, ANIMALS AND MAN.

By D. KEILIN, Sc.D.

Beit Memorial Research Fellow.

From the Molteno Institute for Research in Parasitology, University of Cambridge.

(With Plate IX and 3 Text-figures.)

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INTRODUCTION.

In this paper I propose to deal with the life history and structure of the early stages of an Acalypterate fly, *Neottiophilum praeustum* (Meigen), the larvae of which live only in the nests of Birds.

A number of nests of various birds, harbouring *Neottiophilum* and other dipterous larvae, have been collected at Tonbridge and kindly sent to me by Mrs A. F. Buxton and Dr P. A. Buxton, to whom I wish to express here my gratitude for supplying me with this rich and interesting material. The study of these larvae gave me also an opportunity to verify once more a generalisation which I proposed some years ago concerning the constant relationship existing between the structure of the pharynx and the mode of life in the larvae of Cyclorhaphous Diptera.

HISTORICAL ACCOUNT.

Neottiophilum praeustum (Meigen 1826) is an Acalypterate fly which was described almost a hundred years ago by Meigen under the name of *Dryomyza praeusta*. A few years later it was found in Britain and recorded by Stephens (1829) in his *Systematic Catalogue of British Insects* (II. p. 317) and in 1853 we find it included in the list of British Insects compiled by Walker with the note: "Generally distributed. Mr Spence informs me that he has reared it from truffles. E.S.I." (II. p. 164). In 1868 Frauenfeld described a fly which he believed to belong to a new species and for which he created even the new genus *Neottiophilum*. Several specimens of this fly, named by him as *Neottiophilum fringillarum* n.g., n.sp., were obtained from pupae lying among the fibres of a finch's nest. The nest with the pupae were found by the ornithologist Tschusis who presented them to the Zoologico-botanical Society of Vienna. In this note Frauenfeld mentions that the nest contained a great number of larvae which he thinks were present when the nest was still occupied by the nestlings. The nest was, however, clean and without excrement or any decomposed vegetable substance and there were no indications that these larvae were the cause of death of any of the nestlings.

In 1881 Bigot described a fly, which he believed to be new, under the name of *Blephariptera cartereani* n.sp., the description being based on a single male specimen caught in the open.

The following year Mik (1882) in his very interesting note on the genus *Neottiophilum* Frauenfeld established the synonymy between the species *Dryomyza praeusta* Meigen 1826, *Neottiophilum fringillarum* Frauenfeld 1868 and *Blephariptera cartereani* Bigot 1881. The species discovered by Meigen he transferred into the genus *Neottiophilum* created by Frauenfeld. According to Mik, this genus contains but one species: *Neottiophilum praeustum* (Meigen 1826) Mik 1882. As to the systematic position of this genus, Mik expresses the view that if one does not establish for it a new family, it can be placed only among the Dryomyzidae.

A year later, Brauer (1883) in his well-known study on dipterous larvae gave a description of the pupa of *N. praeustum* in three lines of print, based probably on the specimens found by the ornithologist Tschusis and seen previously by Frauenfeld (1868). This description is, however, expressed in very general terms and can hardly serve even for the ordinary recognition of this pupa.

In 1887, Mik, in a short note on "a rare Dipteron" mentions that he had found one male of *N. praeustum* in Waldberg (Niederöstreich) and he refers to the paper of Frauenfeld (1868) and the discovery by Tschusis of the pupae of this fly in a finch's nest. In 1894 Mik records that another male of this fly had been caught by a schoolmaster, Wüstnei, on the window of the school at Sonderburg (Schleswig-Holstein) on the 24th April, 1891, and mentioned that the school house harboured under its roof numerous sparrow's nests. In the same note he adds that Stroble (1894, p. 86) in his paper on the Diptera of

Steiermark refers to Schieferer having found a female of this fly in Graz. The next year Röder (1895) indicates a few new places where *N. praeustum* has been found (Harz, Schleswig, etc.). Verrall's list of British Diptera published in 1901 contains the species *Neottiophilum praeustum* presumably on the strength of Stephens' and Walker's statements.

Becker (1902) having examined Meigen's type specimen (a female) in the Paris collection, confirmed Mik's statement as to its identity with Frauenfeld's *Neottiophilum fringillarum*. Later (in 1905) the same author, in his catalogue of Palaearctic Diptera, places the genus *Neottiophilum* Frf. with the genera *Dryomyza* Fall. and *Actora* Meig. within the family of Dryomyzidae, but in his references the few British records of *Neottiophilum* which we have mentioned above are overlooked.

Charbonnier (1912), in his list of Diptera of the Bristol district, also records *N. praeustum* as found at Wotton-under-Edge by V. R. Perkins.

Hendel in 1916 and 1922 separates the genus *Neottiophilum* from the family of Dryomyzidae and creates for it a new family: Neottiophilidae.

Engel (1920), in a paper on non-pupiparous Diptera parasitic on birds, referring to *Neottiophilum praeustum*, mentions only the observations of Frauenfeld and Mik quoted above. Finally Bezzi (1922) in his bibliography of non-pupiparous Myiodaria parasitic on birds, referring to the geographical distribution of this species, says: "At present known only from Central Europe: France, Germany and Austria. The adult seems to be rare, and has been found mostly on windows in houses: it lives probably on trees....The fly was bred from puparia found in nests of *Fringilla coelebs* and of *Passer domesticus*, but almost nothing is known about the larva." Like most other authors he has overlooked the British records of this fly.

All these records which we have examined in chronological order show that *Neottiophilum praeustum* is rather a rare insect, known in Britain, France, Germany and Austria and bred but once from pupae found by Tschusis in the nest of a finch.

UNPUBLISHED RECORDS.

In addition to these published records, some unpublished observations concerning the distribution and the mode of life of this fly have been obtained from several entomologists. Mr F. E. Edwards kindly informed me that in the collection of the British Museum there are several specimens of *N. praeustum* collected mostly in the middle of May. These were taken in 1908 by Lt.-Col. Yerbury at Tarrington (Hereford) and in the New Forest (Lyndhurst and Fordingbridge). Other specimens have also been collected by J. C. Adams in the New Forest.

Dr J. Villeneuve of Rambouillet (France) informed me in 1917 that he had never caught this fly in the open but had bred it from a sparrow's nest at Rheims.

Mr J. E. Collin, in a letter dated 24th of August this year, in addition to most useful information concerning the literature on various Dryomyzidae

writes about *Neottiophilum praeustum*: "I have personally bred it freely from the nests of thrushes and blackbirds."

Finally Major W. C. Patton in a letter of 28th of August last kindly informed me of his most interesting observations on the mode of life of this fly. In his letter he writes: "I first collected the larvae of *N. praeustum* in the summer of 1919 from the nest of a Greenfinch; I then noted that they contained the blood of the nestlings. Since then I have collected larvae, and my eldest son has also, from the nests of Chaffinches and Greenfinches, but we have never found them in the nests of Thrushes and Blackbirds, though we have searched for them on many occasions. It is very common in my garden but only in the nests noted."

PERSONAL OBSERVATIONS.

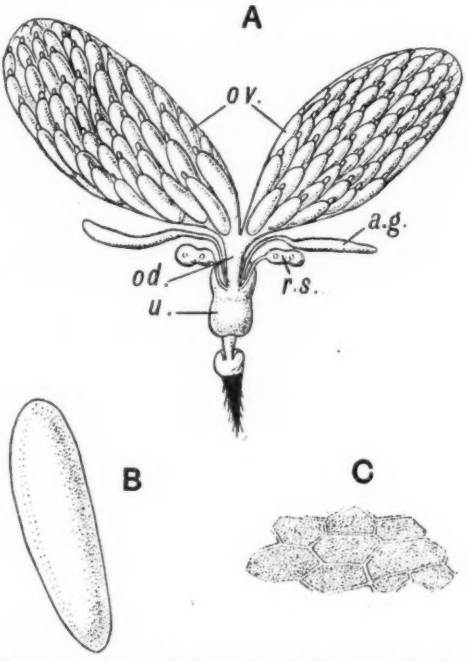
On the 13th of June, 1916, the writer received from Mrs and Dr Buxton a nest of a linnet, *Acanthis canabina*, collected at Tonbridge. This nest already deserted by the nestlings was mainly composed of wool and was clean and dry and completely devoid of all decomposed organic substance. It contained, however, 45 larvae of a fly crawling between the fibres of the wool. These larvae, which one could easily recognise as belonging to a Cyclorhaphous fly, were white, and ready to pupate. Five of them were sacrificed for the study of the morphology while the remaining 40 were left in the nest. They remained, however, in the same stage for a long time and only at the beginning of November began to pupate. On the 3rd, fourteen pupae, twenty living and six dead larvae were found. The adult flies began to hatch between the end of March (29. iii.) and the end of April (23. iv.) of the following year and were then identified as *Neottiophilum praeustum* (Meigen). The room where the larvae were kept throughout the winter was warmed during the day but at night its temperature was more or less equal to that of the outside. The adults hatched in the laboratory and fed greedily on honey. They were somewhat slow in movement and very easy to catch. The males and the females copulated readily and one female was observed with two males attached to it. This female subsequently died when only a fortnight old and the dissection showed that the ovaries were well developed and contained 105 completely formed eggs. The females did not, however, oviposit in captivity and on the 28th May all the adults were dead. No direct observations on feeding habits of the larvae could be made, as the nest was already deserted by the birds and the larvae were full grown and past their age of feeding. There is, however, ample evidence that they live as blood sucking or intermittent parasites of birds and are similar in habits to those of *Phormia* and *Passeromyia*. The first indication of this mode of feeding is shown by the fact that the nest, though harbouring as many as 45 full grown larvae, was devoid both of remains of dead birds and of decomposed organic substance. This was so also in the case of the nest collected by Tschusis and studied by Frauenfeld. The next and perhaps the most important indication is the observation of Patton, who

noticed that the larvae of *N. praeustum* contained the blood of the birds. Finally, as we shall see in the anatomical description, the larva shows clearly the character of a biontophagous mode of life, that is, the habit of feeding upon fresh and living substance[1].

The larvae of *Neottiophilum* have been also found in a nest of a Blackcap [*Sylvia atricapilla* (L.)] collected at Tonbridge in July, 1920, and sent to me by Dr Buxton.

INTERNAL GENITAL ORGANS OF THE FEMALE AND THE EGGS.

The females of *Neottiophilum* dissected from 10 to 14 days after their emergence from the pupa already showed well-developed ovaries (Text-fig. 1 *A*)



Text-fig. 1. *Neottiophilum praeustum*. *A*. internal genital organs of a female; *a.g.* accessory glands; *o.d.* oviduct; *ov.* ovary with ripe eggs; *r.s.* receptacula seminis; *u.* uterus. ×14. *B*. egg. ×44. *C*. a portion of egg's surface. ×240.

with about 100 to 120 eggs to each fly. The two ovaries (*ov.*) by means of a very short common oviduct (*od.*) open into the medio-ventral side of the muscular uterus (*u.*). At the base of the oviduct there opens a pair of accessory glands (*a.g.*), which in this species are rather short and also a pair of pear-shaped receptacula seminis (*r.s.*). The egg (*B*) is elongated, slightly curved,

[1] Spence's statement, quoted by Walker, that he had reared this species from truffles may perhaps be explained by supposing that the insects, either as larvae or pupae, had fallen from the nest of a bird and had subsequently been picked up accidentally with the truffles.

rounded at one extremity and almost pointed at the other. Its surface when examined under higher magnification shows a fine granular structure forming pentagons of various sizes.

STRUCTURE OF THE LARVA.

The full grown larva of *Neottiophilum praeustum* (Pl. IX, Fig. 1) is 10·5 mm. long and 2·8 mm. across the middle. The anterior portion of the body is narrow and pointed, while the posterior end is wide and truncated dorsally. The segmentation is not very clearly marked and is partly masked by accessory transverse folds and various protuberances, especially those which surround the sensory papillae. But, by careful examination of the larva, one can distinguish that its body is composed of a small pseudocephalon or head, three thoracic and eight abdominal segments. The *head or pseudocephalon* (Pl. IX, Fig. 2), as is usually the case in Cyclorhaphous Diptera, is divided by means of a deep longitudinal groove (*m.g.*) into two lateral lobes, each bearing sensory organs and various chitinous projections. All these structures are specially well seen when the head is examined from its ventral side. The antennae (*an.*) are composed of two portions: a basal, more strongly chitinised segment, of brownish colour and a terminal, bell-shaped segment which in this species is slightly elongated. Each of the maxillary palps (*m.p.*) comprises about 10 small sensory papillae surrounded by a strong chitinous ring, the whole making but a slight protrusion from the surface of the cephalic lobes. The strong chitinous ring is surrounded by a series of incomplete chitinous striae or folds and three sensory papillae. More posteriorly the ventral surface of the head bears a pair of well-developed sensory organs composed of several papillae. These organs exist in all Cyclorhaphous Dipterous larvae and, as we have previously seen (1915), their nerve ganglion is connected with that of the maxillary palps.

More posteriorly the ventral side of the pseudocephalon shows the protruding terminal portion of lateral hooks (*l.h.*) and quite close, two rows of well-developed and strongly chitinised hooks forming a strong scraper-like structure (*scp.*) on either side of the mouth. In addition to these hooks the ventral surface of the head bears a series of small hooklets, some of which are connected in rows, while the rest are isolated and scattered. In the posterior, medio-ventral, portion of the head there is a soft conical projection which probably corresponds to the labium. The characteristic sensory structures, which represent the labial palps, could not, however, be detected upon it.

Each of the *three thoracic and eight abdominal* segments shows around its anterior portion a series of sinuous rows of small transparent hooklets. These segments show also small transparent vesicular protrusions, each bearing a sensory organ in the form of a pit. These vesicular protrusions are usually surrounded by one, two, or more concentric chitinous ridges. In addition to these sensory papillae, the ventral side of each of the three thoracic segments bears one pair of "vestigial sensory legs" each composed of three very small sensory hairs connected with the opening of the imaginal discs of the legs (cf. Keilin, 1915).

Respiratory system. The full grown, or third stage larva, is amphipneustic, bearing its functional spiracles on the prothorax and at the posterior end of the abdomen. The prothoracic spiracles (Pl. IX, Fig. 3) show a very well developed felt chamber ending in thirteen short spiracular papillae. The postabdominal spiracles (Figs. 4 and 5) lie in the middle of the truncated surface of the eighth abdominal segment. Each spiracular plate shows three characteristic oval papillae with strongly developed chitinous borders. In the external corner of each papilla there is the small circular opening (*o.*) of the perispiracular glands. The papillae appear in this case to be covered with a membrane having a central longitudinal cleft. Between the papillae there may be seen small chitinous hairs, probably of sensory function. The three papillae are surrounded by a common chitinous ring which is supported by a dark chitinous structure projecting from the surface of the segment and bearing a clear spot, which represents the external scar of the spiracle (*s.e.*).

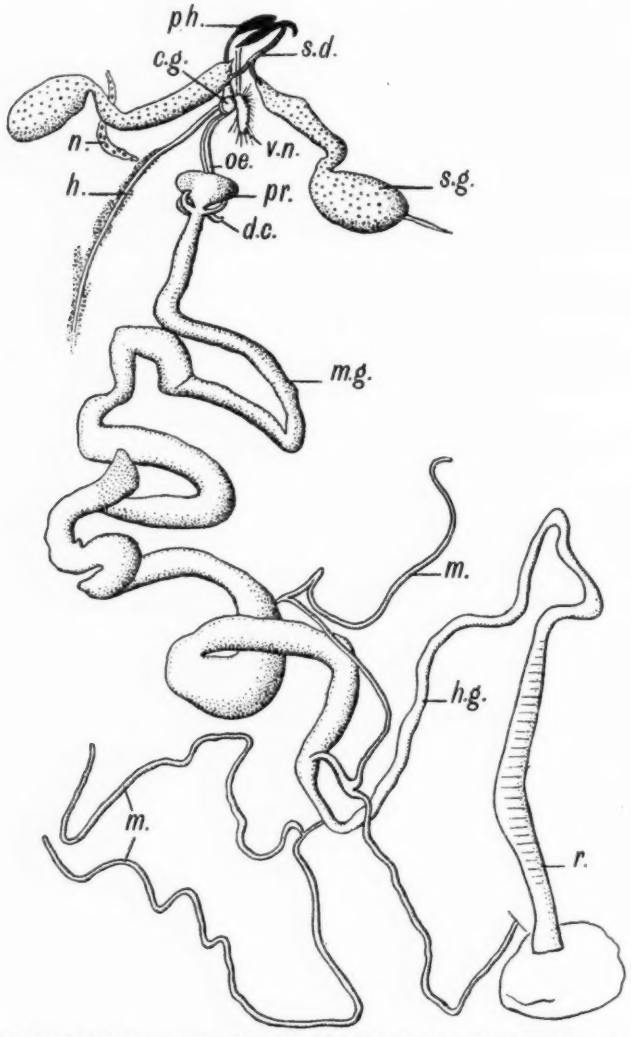
The cephalopharyngeal armature (Pl. IX, Figs. 6, 7 and 8) in a third stage of a Cyclorhaphous Dipterous larva is usually composed of three portions: (1) mouth parts, (2) intermediate or hypopharyngeal portion, and (3) basal or pharyngeal portion.

(1) The mouth parts are represented here by a pair of well-developed lateral hooks (*l.h.*) strongly chitinised and of almost uniformly black colour, except in the middle of the wide triangular portion where there is a dark brown spot. These two hooks are articulated with the next intermediate portion (*i.*).

(2) The intermediate portion of this larva differs from that of most other Cyclorhaphous Diptera by being completely united to the basal portion. The two lateral chitinous structures of the intermediate portion are united ventrally by means of two crescentic rods, which represent a local hardening of the soft and transparent chitinous membrane covering the ventral surface of the pharynx. The duct of salivary glands (*s.*) opens in the middle of the posterior rod (*h.p.*) and, just behind the anterior rod (*h.a.*), the thin chitinous membrane of the pharynx shows two chitinous plates of irregular shape, each bearing four sensory papillae opening into the lumen of the pharynx (Pl. IX, Fig. 7, *sp.*).

(3) The basal or pharyngeal portion is composed of two lateral, strongly-chitinised plates (*Ph.*) with the deep posterior emarginations (*e.*). Figs. 6 and 8 (Pl. IX), which represent this portion seen respectively from the ventral and lateral sides, give a sufficiently clear idea of its structure. These figures show also that the ventral side or floor of the pharynx is smooth and without any ridges projecting into the lumen. This character is specially well seen in the transverse sections of the pharynx represented in Figs. 10 and 11 (Pl. IX). Now the structure of the floor of the pharynx, the presence or absence of the longitudinal ridges gives, as has been previously shown (Keilin, 1912, 1915), the most important indications as to the mode of feeding of a Cyclorhaphous Dipterous larva, and we shall have, therefore, to dwell in more details upon the significance of this character.

Alimentary canal and other organs (Text-fig. 2). The pharynx communicates with a short oesophagus (*oe.*) which opens into a proventriculus (*pr.*). The



Text-fig. 2. *Neottiophilum praeustum*, dissection of the larva: *c.g.* cerebral ganglion; *d.c.* digestive coecae; *h.g.* hind-gut; *h.* heart surrounded by pericardial cells; *m.* malpighian tubes; *m.g.* mid-gut; *n.* ventral nephrocytes; *oe.* oesophagus; *ph.* pharynx; *pr.* proventriculus; *r.* rectum; *s.d.* salivary duct; *s.g.* salivary glands; *v.n.* ventral nerve mass. $\times 10\frac{1}{2}$.

latter is wide and flattened anteriorly, but narrow posteriorly at the point where it joins the midgut and the four short digestive coeca (*d.c.*). The midgut

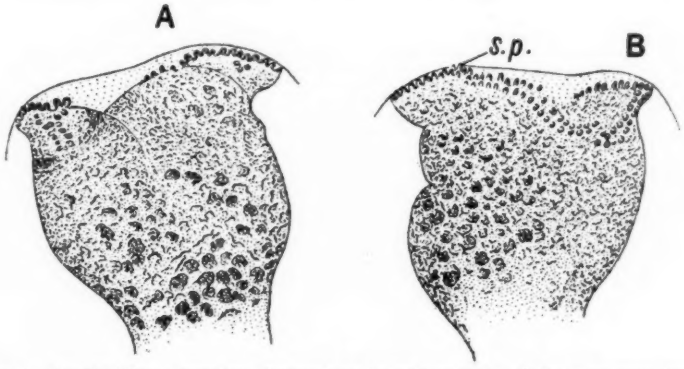
(*m.g.*) is long and forms several loops in the body cavity. At its posterior end, where it joins with the hindgut (*h.g.*), two pairs of malpighian tubes (*m.*) arise: a ventral and a dorsal pair. The hindgut, which is only half the length of the midgut, opens ventrally on the eighth abdominal segment.

The salivary glands (*s.g.*) are well developed; their short ducts unite into one median salivary duct (*s.d.*) which opens in the middle of the posterior rod of the intermediate or hypopharyngeal portion of the armature.

The central nervous system is of extremely small size compared to that of the other organs. Text-fig. 2 shows the heart with the pericardial nephrocytes, as well as the ventral nephrocytes which correspond to the "guirlandenformigez Zellenstrang" of Weismann (*n.*).

PUPARIUM AND PUPA.

The puparium (Pl. IX, Fig. 12), when completely formed is blackish and retains the characteristic shape of the larva. The anterior end is pointed,



Text-fig. 3. *Neottiophilum praeustum.* Internal prothoracic spiracles of the pupa seen from two different sides, showing: *s.p.* two double rows of spiracular papillae. × 142.

while the posterior is widened. It shows the segmentation of the larva. The pupa is devoid of the external prothoracic, horn-like spiracles, which are common in Cyclorhaphous Diptera, but is provided with a pair of internal prothoracic spiracles lying within the puparium. These spiracles (Text-fig. 3) are composed of a well-developed felt chamber, the terminal portion of which is bifurcated and forms two lobes, each bearing two rows of small spiracular papillae(*sp.*).

STRUCTURE OF THE PHARYNX IN A CYCLORHAPHOUS DIPTEROUS LARVA AND ITS RELATION TO FEEDING HABITS: PARASITIC AND PSEUDO-PARASITIC MYIASIS IN PLANTS, ANIMALS AND MAN.

In 1912 and again in 1915, having examined the structure of the pharynx of a great number of Cyclorhaphous Dipterous larvae belonging to various

families and various ethological groups, the writer arrived at the following conclusion: *All larvae living as parasites in animals and plants, predaceous and blood-sucking larvae, or those which live in the uterus of their mother, in other words all larvae which feed upon living organic substance, and which we shall call* biontophagous, *have the pharynx devoid of longitudinal ridges. On the other hand, in all* saprophagous *larvae, which live upon decomposed organic animal or vegetable substance, the floor of the pharynx is provided with well-developed, longitudinal ridges.* This generalisation is based on a very great number of larvae examined. To the lists published in 1912 and 1915 may now be added a number of other species. The late J. C. Nielsen informed the writer that all parasitic Tachinidae and Dexiidae which he had examined were devoid of pharyngeal ridges. The same can be applied to the larvae of *Melinda* parasitic in snails (Keilin, 1919) and to various predaceous larvae of Anthomyidae. The number of biontophagous larvae now known to be devoid of pharyngeal ridges is very great, and the same may be said of the list of saprophagous larvae which on examination have, in every case, revealed the presence of ridges. Among hundreds of species which have verified this generalisation but very few exceptions have been found; and even these exceptions, when carefully examined, seem to corroborate the same generalisation. Thus among the Trypetidae which live upon various plants, the larvae of *Trypeta* and *Urophora* living in the flower heads of Compositae are devoid of ridges, while the larvae of *Anastrepha*, *Ceratitis*, *Ragoletis* and *Dacus* which attack the fruits of various trees are provided with well-developed ridges. This seems to indicate that the conditions of life in some of the fruits at least, are somewhat similar to the saprophagous mode of life. The fruits which are attacked by these larvae undergo a very rapid decomposition or digestion due either to bacteriae, or yeasts brought in from the surface of the fruit or to ferments liberated by the larvae from the cells of the fruit itself. In the case of the *Dacus oleae* attacking olive fruits, which are rather hard and not easily liquefied, it was found by Petri (1905–1909) that the larvae harbour in their digestive coeca a symbiotic bacterium: *Bacterium savastoni* accompanied by *Ascobacterium luteum*. These bacteria pass from the larvae to the pupae and so to the adult flies. The eggs of *Dacus oleae*, when laid into the pulp of the olive, are covered by these bacteria which actively multiply in the air chambers of the complicated micropyle. The larvae thus become infected before hatching from the eggs [see Buchner, P. (1921), Tier and Pflanze in intrazellularer Symbiose. Berlin].

The few Anthomyid larvae like *Pegomyia* which form galleries in the leaves of plants, in spite of their being phytophagous, show the longitudinal ridges. But here the galleries are not isolated as is the case of Agromyzinae and Phytomyzinae (devoid of ridges), they form, on the contrary, large infected patches under the epidermis, and the larvae often crawl out from one place and start their attack on another part of the same leaf. Moreover, in these larvae the pharyngeal ridges are very much reduced in size.

The relation between the structure of the pharynx and the mode of feeding

of larvae, expressed in the generalisation made above, enabled the writer on several occasions to detect the mode of life of a larva from the mere examination of its pharynx, a diagnosis which was subsequently, without exception, confirmed by observation *in vivo*. By this means the larvae of many flies found in decomposing organic matter were discovered to be in reality biontophagous, predaceous upon other truly saprophagous larvae or parasitic (Keilin, 1912, 1915) upon other animals living in the same medium. In the same way larvae (Phoridae) found in various dead insects were discovered not to have caused the death of those insects, but to have invaded their already diseased or dead and partly decomposed bodies. This generalisation can be applied in the study of *Myiasis in animals and man* and will enable the investigator to separate the larvae into two groups: (1) those which invade fresh healthy tissue—biontophagous larvae, devoid of pharyngeal ridges, and (2) larvae which invade diseased tissue and by means of their hooks carry infection into the healthy parts of the host, feeding only upon the products of decomposition, products prepared for them by the micro-organisms introduced. We shall thus have to separate true parasitic larvae—the cause of primary myiasis—from those larvae which merely invade the infected wounds or cavities and are the cause of secondary or pseudoparasitic myiasis.

It is important to add that the structure of the pharynx, the presence or absence of the ridges, can often be seen by transparency in the living larvae. In preserved specimens, whether dissected or not, the ridges can be detected when specimens are mounted in Canada balsam, cedar wood oil or gum arabic. Finally, the structure of the pharynx can be studied in the cephalopharyngeal armature extracted from the puparium after the emergence of the adult fly, an empty puparium often giving much information as to the mode of life of the larva.

Having determined the relationship between the structure of the pharynx and the feeding habits in the larvae of other Cyclorhaphous Diptera, we may now apply the same generalisation to the larva of *Neottiophilum*.

We have previously seen that the pharynx in *Neottiophilum* larva is completely devoid of longitudinal ridges projecting into the lumen of the pharynx. To illustrate this character more clearly we have only to compare the pharynx of *Neottiophilum* with that of the larva of *Anthomyia procellaris* Rond. which have also been found in nests of various birds, though saprophagous and feeding upon the decomposed organic substances. These larvae show very well-developed longitudinal ridges (Pl. IX, Fig. 9) forming on the ventral side of the pharynx a series of longitudinal tubes communicating with the pharynx by means of long and narrow slits. This difference brings us to the conclusion that the larvae of *Neottiophilum* are biontophagous, feeding upon living substance, a conclusion which corroborates Patton's discovery of the blood of the nestlings within the larvae. The mode of life of *Neottiophilum praeustum* seems to be similar to that of Calliphorine flies of

the genus *Phormia*[1] or those of the Anthomyine genus *Passeromyia*, the larvae of both of which live in the nests of various birds and are blood-sucking. Probably the ventral rows of hooks on either side of the mouth, which are so characteristic of the larvae of *Neottiophilum*, are used for anchoring the larva to the host, while the lateral hooks are driven under its skin. They remind one somewhat of the ventral cephalic hooks of the blood-sucking larvae of *Auchmeromyia luteola* parasitic on man.

LIFE HISTORY OF *DRYOMYZA* AND *ACTORA* AND SYSTEMATIC POSITION OF *NEOTTIOPHILUM*.

The genus *Neottiophilum* Frauenfeld is placed by the majority of entomologists within the family of Dryomyzidae which contains but two other genera: *Dryomyza* Fallen and *Actora* Meigen. It would be interesting now to compare the life history and larval anatomy of *Neottiophilum praeustum* with those of *Dryomyza* and *Actora*. Unfortunately our knowledge of the latter is very limited, and for the genus *Dryomyza*, which comprises about four species, all we know is expressed in a few words by Macquart (1835, II. p. 396) almost 90 years ago, namely: "Their larvae develop in fungi." This information has been quoted several times by various authors like Scholtz (1850), Schiner (1854), Brauer (1883), etc., but seems never to be confirmed, nor has the larva ever been described or figured.

We know a little more of the genus *Actora* which, according to the Palaearctic catalogue, comprises two species. The adult flies of *A. aeustum* have been observed by Guérin and later by Joseph (1880) upon the scum of the waves or upon floating sea weeds round the shores of Heligoland and Sylt. According to Joseph (1880) they seem to secrete a peculiar wax-like substance which covers their body and keeps it dry even when splashed with sea water. The larvae of these flies live in sea weeds (*Fucus*) which are left by the sea and are only temporarily wetted by the latter. For pupation the larvae bore into the sand 5–8 cm. deep and 14–18 days after pupation the emergence of the adult flies takes place. The sea water seems to be indispensable for the development of the larvae which die when the sea weed is kept away from the sea water, or when wetted with fresh water. Unfortunately Joseph does not even attempt to describe the larvae. More recently, Gadeau de Kerville (1894) found Dipterous larvae on the Chausey Islands (Manche) living in muddy sand under a stone and immersed by sea water at regular intervals. This author did not breed the larvae, and gave only a short description with a few figures. Some of his specimens preserved in alcohol have been examined by Mik who reported that judging from the size (10–15 mm. long), they must belong to the genus *Actora*. This is practically all we know about the genera *Dryomyza* and *Actora*, and the only point we can certainly deduce from it is the *saprophagous* habit of their larvae.

[1] The larvae of *Phormia azurea* which I have found in the nests of a Chaffinch (*Fringilla coelebs*) and Spotted fly-catcher (*Muscicapa griseola*) and which are known to be intermittent blood-suckers, have also the pharynx of a typical biontophagous larva, being devoid of longitudinal ridges.

The peculiar characteristic of *Neottiophilum* in the larval stage as a blood-sucking parasite of birds seems thus to corroborate the views of Hendel (1916 and 1922) who separated this genus from the family of DRYOMYZIDAE and placed it in a new family of NEOTTIOPHILIDAE created by him.

SUMMARY.

1. *Neottiophilum praeustum* (Meigen 1826) is an Acalypterate fly, the larva of which inhabits the nests of various birds, *e.g.* Greenfinches, Chaffinches, Linnets, Thrushes and Blackbirds.

2. The structure of the early stages of this fly namely eggs, larva and pupa is here described for the first time.

3. Hendel's view that *Neottiophilum* should be separated into a new family is confirmed.

4. The larvae of *Neottiophilum* live as intermittent blood-sucking parasites upon the birds. Their feeding habits are similar to those of *Phormia* and *Passeromyia*.

5. The structure of the pharynx in Cyclorhaphous Dipterous larvae gives important indications as to the mode of feeding. Those larvae which are provided with longitudinal ridges are saprophagous or living upon decomposed vegetable or animal substances, while those which are devoid of ridges are biontophagous or feeding upon living substances (parasites in plants and in animals, predaceous or living in the uterus of the mother).

6. This generalisation, when applied to the study of myiasis in plants, animals and man, enables us to separate them into two categories: (1) primary or parasitic myiasis and (2) secondary or pseudoparasitic myiasis, these being either accidental (intestinal) or following upon bacterial infection.

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EXPLANATION OF PLATE IX.

All figures, except Fig. 9, are of *Neottiophilum praeustum*.

Fig. 1. Full grown larva of *Neottiophilum praeustum* seen from left side: *d.* dorsal and *v.* ventral sides; *s.p.* postabdominal spiracles. ×8·5.

Fig. 2. Head of the larva, ventral view: *an.* antennae; *c.* sensory papillae connected with *m.p.* maxillary palps; *m.g.* median groove; *l.h.* lateral hooks; *scp.* scrapers. ×160.

Fig. 3. Prothoracic spiracles: *t.* tracheal trunk; *s.i.* internal scar; *sp.* spiracular papillae. ×160.

Fig. 4. Postabdominal pair of spiracles: *d.* dorsal and *v.* ventral sides of the larva. ×50.

Fig. 5. Right postabdominal spiracle showing: *cl.* spiracular clefts; *o.* openings of perispiracular glands; *s.e.* external scar. ×120.

Fig. 6. Buccopharyngeal armature of the larva unfolded and seen ventrally: *e.* lateral emargination; *h.a.* anterior hypopharyngeal rod; *h.p.* posterior hypopharyngeal rod; *i.* intermediate or hypopharyngeal portion of the armature; *l.h.* lateral hooks; *p.h.* pharyngeal or basilar portion of the armature. ×50.

Fig. 7. Anterior hypopharyngeal crescent shaped rod showing *sp.* two posterior chitinous plates with sensory papillae.

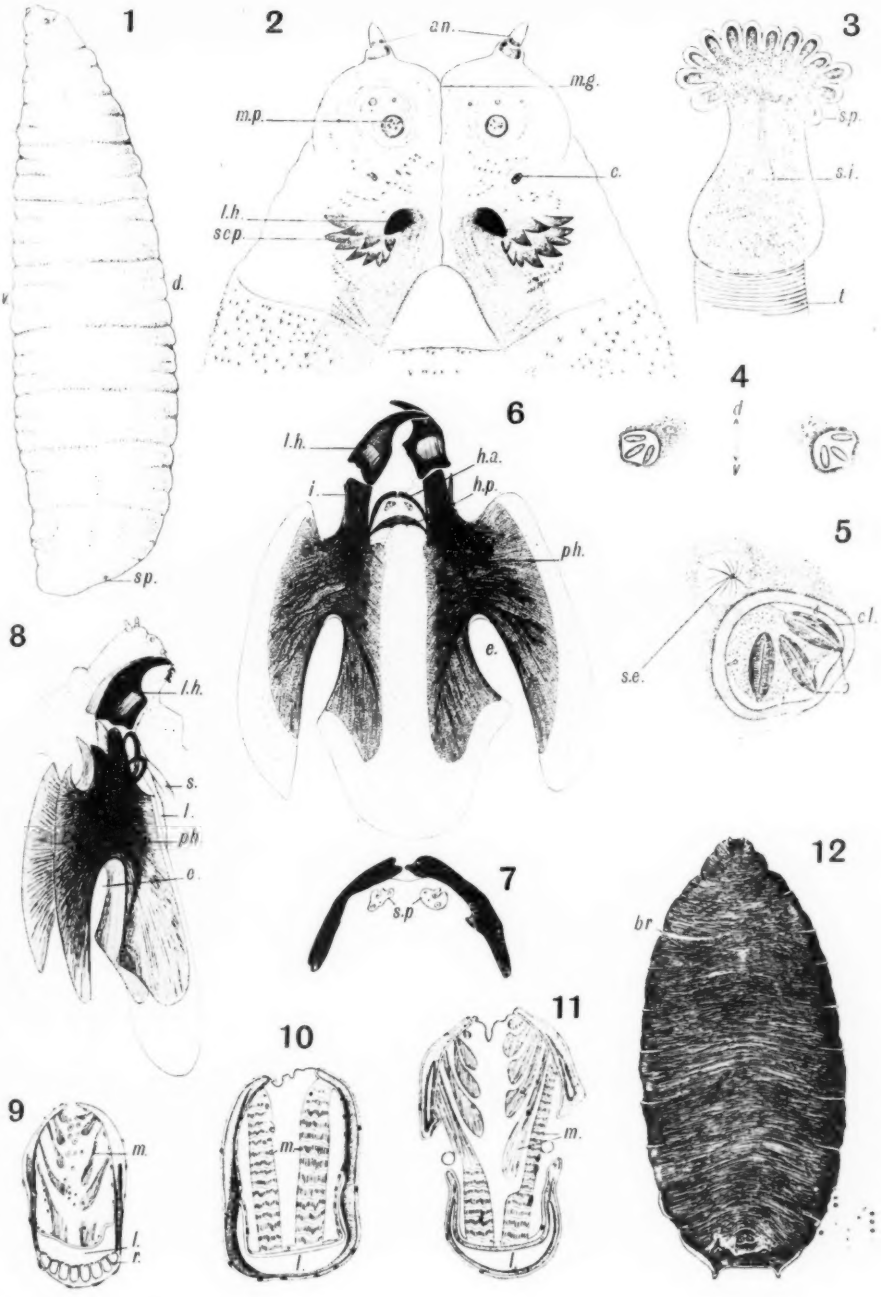
Fig. 8. Buccopharyngeal armature seen from right side: *e.* lateral emargination; *l.* lumen of the pharynx; *l.h.* lateral hooks; *p.h.* pharyngeal or basal portion of armature; *s.* salivary duct. ×50.

Fig. 9. *Anthomyia procellaris* Rond. Transverse section of the pharynx of a saprophagous larva showing *l.* pharyngeal lumen; *m.* dilatatory muscles; *r.* longitudinal ridges characteristic of saprophagous mode of life. ×95.

Figs. 10 and 11. Transverse section of pharynx in the larva of *Neottiophilum praeustum* showing biontophagous type devoid of longitudinal ridges. (Letters as in Fig. 9.) ×95.

Fig. 12. Puparium of *Neottiophilum praeustum* seen ventrally showing *br.* line of breaking due to emergence of the fly. ×8·5.

(*MS. received for publication* 10. X. 1923.—Ed.)



D. Keilin and H. C. Gillings del.